JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1924.

(INCORPORATED 1881.)

VOL. LVIII.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET, SYDNEY.

ISSUED AS A COMPLETE VOLUME, MAY 1925

CONTENTS.

VOLUME LVIII.

NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. × $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors

FORM OF BEQUEST.

I bequeath the sum of £ to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vols.	I—XI	Transactions of the Royal Society	N.S.W.,		1867—1877,		„
„	XII	Journal and Proceedings	„	„	1878,	„ 324,	price 10s.6d.
„	XIII	„ „ „	„	„	1879,	„ 255,	„
„	XIV	„ „ „	„	„	1880,	„ 391,	„
„	XV	„ „ „	„	„	1881,	„ 440,	„
„	XVI	„ „ „	„	„	1882,	„ 327,	„
„	XVII	„ „ „	„	„	1883,	„ 324,	„
„	XVIII	„ „ „	„	„	1884,	„ 224,	„
„	XIX	„ „ „	„	„	1885,	„ 240,	„
„	XX	„ „ „	„	„	1886,	„ 396,	„
„	XXI	„ „ „	„	„	1887,	„ 296,	„
„	XXII	„ „ „	„	„	1888,	„ 390.	„
„	XXIII	„ „ „	„	„	1889,	„ 534,	„
„	XXIV	„ „ „	„	„	1890,	„ 290,	„
„	XXV	„ „ „	„	„	1891,	„ 348,	„
„	XXVI	„ „ „	„	„	1892,	„ 426,	„
„	XXVII	„ „ „	„	„	1893,	„ 530,	„
„	XXVIII	„ „ „	„	„	1894,	„ 368,	„
„	XXIX	„ „ „	„	„	1895,	„ 600,	„
„	XXX	„ „ „	„	„	1896,	„ 568,	„
„	XXXI	„ „ „	„	„	1897,	„ 626,	„
„	XXXII	„ „ „	„	„	1898,	„ 476,	„
„	XXXIII	„ „ „	„	„	1899,	„ 400,	„
„	XXXIV	„ „ „	„	„	1900,	„ 484,	„
„	XXXV	„ „ „	„	„	1901,	„ 581,	„
„	XXXVI	„ „ „	„	„	1902,	„ 531,	„
„	XXXVII	„ „ „	„	„	1903,	„ 663,	„
„	XXXVIII	„ „ „	„	„	1904,	„ 604,	„
„	XXXIX	„ „ „	„	„	1905	„ 274,	„
„	XL	„ „ „	„	„	1906,	„ 368,	„
„	XLI	„ „ „	„	„	1907,	„ 377,	„
„	XLII	„ „ „	„	„	1908,	„ 593,	„
„	XLIII	„ „ „	„	„	1909,	„ 466,	„
„	XLIV	„ „ „	„	„	1910,	„ 719,	„
„	XLV	„ „ „	„	„	1911,	„ 611,	„
„	XLVI	„ „ „	„	„	1912,	„ 275,	„
„	XLVII	„ „ „	„	„	1913,	„ 318,	„
„	XLVIII	„ „ „	„	„	1914,	„ 584,	„
„	XLIX	„ „ „	„	„	1915,	„ 587,	„
„	L	„ „ „	„	„	1916,	„ 362,	„
„	LI	„ „ „	„	„	1917,	„ 786,	„
„	LII	„ „ „	„	„	1918,	„ 624,	„
„	LIII	„ „ „	„	„	1919,	„ 414,	„
„	LIV	„ „ „	„	„	1920,	„ 312,	price £1 1s.
„	LV	„ „ „	„	„	1921,	„ 418,	„
„	LVI	„ „ „	„	„	1922,	„ 372,	„
„	LVII	„ „ „	„	„	1923,	„ 421,	„
„	LVIII	„ „ „	„	„	1924,	„ 366,	„

Royal Society of New South Wales.

OFFICERS FOR 1924-1925.

Patron

HIS EXCELLENCY THE RIGHT HONOURABLE HENRY WILLIAM, BARON FORSTER, P.C., G.C.M.G.

Governor-General of the Commonwealth of Australia.

Vice-Patron:

HIS EXCELLENCY SIR DUDLEY RAWSON STRATFORD de CHAIR, K.C.B., M.V.O.

Governor of the State of New South Wales

President:

C. ANDERSON, M.A., D.Sc.

Vice-Presidents.

Prof. C. E. FAWSITT, D.Sc., Ph.D.
J. NANGLE, O.B.E., F.R.A.S.
E. C. ANDREWS, B.A., F.G.S.
R. H. CAMBAGE, F.L.S.

Hon. Treasurer

Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries.

Prof. O. U. VONWILLER, B.Sc.
G. A. WATERHOUSE, D.Sc., B.E., F.E.S.

Members of Council:

Prof. L. A. COTTON, M.A., D.Sc.
Prof. Sir EDGEWORTH DAVID, K.B.E., C.M.G., D.S.O., F.R.S., D.Sc.
W. S. DUN.
R. GREIG-SMITH, D.Sc., M.Sc.
T. H. HOUGHTON, M.Inst.C.E., M.I.M.E.*
W. POOLE, M.E., M.Inst.C.E., M.I.M.M., M.I.E., Aust., M.Am.M.I.F.
H. G. SMITH, F.C.S.†
Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.
Prof. R. D. WATT, M.A., B.Sc.
W. G. WOOLNOUGH, D.Sc., F.G.S.

---

* Deceased 26th September, 1924. † Deceased 19th September, 1924.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal. The numerals indicate the number of such contributions.

‡ Life Members

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch M., 185 Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1918		Adam, George Hyslop, 'Lintrose,' Warren Road, Marrickville.
1904		Adams, William John, M. I. MECH. E., 175 Clarence-street
1898		Alexander, Frank Lee, William-street, Granville
1905	P 2	Anderson, Charles, M.A., D.Sc. *Edin.*, Director of the Australian Museum, College-street. *President.*
1909	P 9	Andrews, Ernest C., B.A., F.G.S., Hon. Mem. Washington Academy of Sciences, Government Geologist, Department of Mines, Sydney. (President, 1921.) *Vice-President.*
1915		Armit, Henry William, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, The Printing House, Seamer-street. Glebe.
1919		Aurousseau, Marcel, B.Sc., 9 Bannerman Street, Cremorne.
1923		Baccarini, Antonio, Doctor in Chemistry (Florence), 12 Roslyndale Avenue, Woollahra.
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1924		Bailey, Victor Albert, M A , D.Phil. Assoc -Professor of Physics in the University of Sydney.
1921		Baker, Rev. Harold Napier, M.A. *Syd.*, St. Thomas' Rectory, North Sydney.
1919		Baker, Henry Herbert, 15 Castlereagh-street.
1894	P 27	Baker, Richard Thomas, The Avenue, Cheltenham.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1919		Bardsley, John Ralph, "The Pines," Lea Avenue, Five Dock.
1896		Barff, H. E., M.A , C.M.G., Warden of the University of Sydney.
1908	P 1	Barling, John, L.S., 'St. Adrians,' Raglan-street, Mosman.
1918		Barr, Robert Hamilton, 37 Sussex-street.
1895	P 9	Barraclough, Sir Henry, K.B.E., B.E., M.M.E., M. INST. C.E., M. I. MECH. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Professor of Mechanical Engineering in the University of Sydney; p.r. 'Marmion,' Victoria-street, Lewisham.
1909	P 2	Benson, William Noel, D.Sc , *Syd.*, B.A., *Cantab.*, F.G.S., Professor of Geology in the University of Otago, Dunedin, N.Z.
1923		Berry, Frederick John, F.C.S., 'Roseneath,' 51 Reynolds-street, Neutral Bay.
1919		Bettley-Cooke, Hubert Vernon, 'The Hollies,' Minter-street, Canterbury.

Elected.		
1923		Birks, George Frederick, c/o Potter & Birks, 15 Grosvenor-st.
1916		Birrell, Septimus, c/o Margarine Co., Edinburgh Road, Marrickville.
1920		Bishop, Eldred George, Belmont-street, Mosman.
1915		Bishop, John, 24 Bond-street.
1913		Bishop, Joseph Eldred, Killarney-street, Mosman.
1923		Blair, Kenneth John, 'Mimpi,' Parsley Road, Vaucluse.
1923		Blakely, William Faris, 'Myola,' Florence-street, Hornsby.
1905		Blakemore, George Henry, Room 32, Third Floor, Commercial Bank Chambers, 273 George-street.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C P. *Lond.*, 'Inglewood,' Florida Road, Palm Beach, Sydney.
1893		Blomfield, Charles E , B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1917		Bond, Robert Henry, 'Elfindale,' Croydon Avenue, Croydon Pk.
1920	P 2	Booth, Edgar Harold, M.C., B.Sc. Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Bradfield, John Job Crew, D.Sc. Eng., M.E., M Inst. C.E , M. Inst E. Aust., Chief Engineer, Metropolitan Railway Construction, Railway Department, Sydney.
1910	P 1	Bradley, Clement Henry Burton, M.B., Ch.M., D.P.H., 'Nedra,' Little-street, Longueville; 211 Macquarie-street.
1876		Brady, Andrew John, L.K. and Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 175 Macquarie-street, Sydney.
1916		Bragg, James Wood, B.A., c/o Gibson, Battle &Co. Ltd.,Kent-st.
1917		Breakwell, Ernest, B.A., B.Sc, Headmaster Agricultural School, Yanco.
1891		Brennand, Henry J. W., B.A., M.B., Ch M. *Syd.*, 203 Macquarie-street; p.r. 73 Milsons Road, Cremorne.
1923		Brereton, Ernest Le Gay, B.Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney.
1919	P 1	Briggs, George Henry, B.Sc., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Brough, Patrick, M.A., B.Sc., B.Sc., (Agr.) (Glasgow), Lecturer in Botany in the University of Sydney.
1923		Brown, Herbert, 'Sikoti,' Alexander-street, Collaroy Beach, Sydney.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Aberdour,' Daniel-street, Granville.
1913	P 7	Browne, William Rowan, D.Sc., Assistant-Professor of Geology in the University of Sydney.
1921		Bull, James Towers, 48 Fort-street, Petersham.
1898		‡Burfitt, W. Fitzmaurice, B.A., M.B., Ch M. B.Sc., *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1919	P 6	Burrows, George Joseph, B.Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney; p.r. Watson-street, Neutral Bay.
1909		Calvert, Thomas Copley, ASSOC. M. INST. C.E., Department of Public Works, Sydney.
1904	P 24	Cambage, Richard Hind, L.S., F.L.S., Under Secretary for Mines, Department of Mines, Sydney; p.r. Park Road, Burwood. (President 1912, 1923). *Vice-President.*

Elected		
1923		Cameron, Lindsay Duncan, Hilly-street, Mortlake.
1907		Campbell, Alfred W., M.D., Ch.M. *Edin.*, 183 Macquarie-street.
1921		Campbell, John Honeyford, M.B.E., Deputy Master of the Royal Mint, Macquarie-street, Sydney.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliff Road, Edgecliff. Australia Chambers, George and Margaret-streets.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney.
1920		Carruthers, Sir Joseph Hector, M.L.C., M.A., *Syd.*, LL.D., *St. Andrews*, 'Highbury,' Waverley.
1903	P 3	Carslaw, Horatio S., M.A., Sc. D., Professor of Mathematics in the University of Sydney.
1913	P 3	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, Henry G., M.D., B.S., Professor of Physiology in the University of Sydney. *Hon. Treasurer.*
1913	P 1	Cheel, Edwin, Botanical Assistant, Botanic Gardens, Sydney.
1909	P 2(	Cleland, John Burton, M.D., Ch M., Professor of Pathology in the University of Adelaide. (President 1917.)
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.* and *Edin.*, 'Roseneath,' 8 Wallis-street, Woollahra.
1896	P 4	Cook, W. E., M.C.E. *Melb.*, M. INST. C.E., Burroway-st., Neutral Bay.
1920		Cooke, Frederick, c/o Meggitt's Limited, 26 King-street.
1913	P 1	Cooke, William Ernest, M.A., F.R.A.S., Government Astronomer and Professor of Astronomy in the University of Sydney, The Observatory, Sydney.
1913	P 1	Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. Bannerman Crescent, Rosebery.
1882		Cornwell, Samuel, J.P., 'Beechworth,' Lane Cove Road, Pymble.
1919		Cotton, Frank Stanley, B.Sc, Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 5	Cotton, Leo Arthur, M.A., D.Sc. Professor of Geology in the University of Sydney.
1919		Cowdery, Edward Henry, L.S., 6 Castlereagh-street, Sydney.
1892	P 1	Cowdery, George R., ASSOC. M. INST. C E., 154 Hay-street; p.r. 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 185 Macquarie-st.
1921		Cresswick, John Arthur, 101 Villiers-street, Rockdale.
1912		Curtis, Louis Albert, L.S., F.I.S. (N.S.W.), V.D., No. 1 Mayfair Flats, Macleay-street, Darlinghurst.
1920		Daněs, Jiri Victor, Ph.D. *Prague*, The University, Prague.
1890		Dare, Henry Harvey, M.E., M. INST. C.E., Commissioner, Water Conservation and Irrigation Commission, Union House, George-street.
1876	P 3	Darley, Cecil West, M. INST. C.E., 'Longheath,' Little Bookham, Surrey, England; Australian Club, Sydney.
1886	P 28	David, Sir Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc, F.R.S., F.G.S., Emeritus Professor of Geology and Physical Geography in the University of Sydney; p.r. 'Coringah,' Sherbrooke-street, Hornsby. (President 1895, 1910.)

Elected		
1919	P 2	de Beuzeville, Wilfrid Alex. Watt, Forestry Assessor, Forest Office, Tumut.
1921		Delprat, Guillaume Daniel, C.B.E., 'Keynsham,' Mandeville Crescent, Toorak, Victoria.
1921		Denison, Sir Hugh Robert, K.B.E., 701 Culwulla Chambers, Castlereagh-street.
1894		Dick, James Adam, C.M.G., B.A. *Syd.*, M.D., Ch M., F.R.C.S. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1924		Dickinson, Reginald E., B.Sc., Eng. *Lond.*, A.M.I.C.E., Chief Mechanical Engineer's Office, N. S. Wales Railways.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1918	P 2	Dodd, Sydney, D.V.Sc., F.R C.V.S., Lecturer in Veterinary Pathology in the University of Sydney.
1913	P 3	Doherty, William M., F.I.C., F.C.S., Second Government Analyst, 'Jesmond,' George-street, Marrickville.
1920		Downing, Reginald George, B.Sc., (Agr.), Field Branch, Department of Agriculture, Sydney.
1908	P 6	Dun, William S., Palæontologist, Department of Mines, Sydney. (President 1918.)
1924		Dupain, George Zephirin, 'Symington,' Parramatta Road, Ashfield.
1924		Durham, Joseph, 120 Belmore Road, Randwick.
1923		Earl, John Campbell, B.Sc., Ph.D., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1919		Earp, The Hon. George Frederick, C.B.E., M.L.C., Australia House, Carrington-street.
1924		Eastaugh, Frederick Alldis, A.R.S.M , F.I.C., Assistant-Professor in Chemistry, Assaying and Metallurgy in the University of Sydney.
1918		Elliott, Edward, c/o Reckitts' (Oversea) Ltd., Bourke-street, Redfern.
1916	P 2	Enright, Walter J., B.A., High-street, West Maitland, N.S.W.
1908		Esdaile, Edward William, 42 Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, c/o Iceton, Faithfull and Maddocks, 25 O'Connell-street.
1921		Farnsworth, Henry Gordon, 'Rothsay,' 90 Alt-street, Ashfield.
1910		Farrell, John, Riverina Flats, 265 Palmer-street, Sydney.
1909	P 7	Fawsitt, Charles Edward, D.Sc, Ph.D., Professor of Chemistry in the University of Sydney. (President 1919). *Vice-President.*
1922		Ferguson, Andrew, 9 Martin Place, Sydney.
1920	P 1	Ferguson, Eustace William, M.B., Ch.M., 'Timbrabongie,' Gordon Road, Roseville.
1923		Fiaschi, Piero, O.B.E., M.D. (Columbia Univ.), D.D.S. (New York) M.R.C.S. (Eng.), L.R.C P. (Lond.), 178 Phillip-street.
1881		Fiaschi, Thos., M.D., M.Ch. *Pisa*, 'The Albany,' 201 Macquarie-st.
1920		Fisk, Ernest Thomas, Wireless House, 97 Clarence-street.

Elected		
1888		Fitzhardinge, His Honour Judge G. H., M.A., 'Red Hill,' Beecroft.
1922		Fleming, Edward Patrick, Under Secretary for Lands, Lands Department, Sydney.
1921		Fletcher, Joseph James, M.A., B.Sc., 'Ravenscourt,' Woolwich Road, Woolwich.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'The Astor,' Macquarie-street.
1920		Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905		Foy, Mark, Elizabeth and Liverpool-streets.
1904		Fraser, James, C.M.G., M. INST. C.E., Chief Commissioner for Railways, Bridge-street.
1907		Freeman, William, 'Ghyll Grange,' 50 Muston-st., Mosman.
1918		Gallagher, James Laurence, M.A. *Syd.*, 'Akaroa,' Ellesmere Avenue, Hunter's Hill.
1921		Godfrey, Gordon Hay, M.A., B.Sc, Lecturer in Physics in the Technical College, Sydney; p.r. 262 Johnston-street, Annandale.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1922	P 3	Grant, Robert, F.C.S., Department of Public Health, 93 Macquarie-street.
1916		Green, Victor Herbert, 19 Bligh-street.
1922	P 1	Greig, William Arthur, Mines Department, Sydney.
1899	P 1	Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay. (President 1915.)
1912		Griffiths, F. Guy, B.A., M.D., Ch.M., 131 Macquarie-street.
1923		Gurney, William Butler, Government Entomologist, Department of Agriculture, Sydney.
1919		Grutzmacher, Frederick Lyle, F.C.S., Church of England Grammar School, North Sydney.
1891	16	‡Guthrie, Frederick B., F.I.C., 'Stanillo' Broughton-street, Moss Vale. (President 1903).
1919		Hack, Clement Alfred, Collins House, 360 Collins-street, Melbourne.
1880	P 5	Halligan, Gerald H., L.S., F.G.S., 97 Elphin Road, Launceston, Tasmania.
1912		Hallmann, E. F., B.Sc., 72 John-street, Petersham.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919		Hambridge, Frank, 58 Pitt-street.
1916	P 1	Hamilton, Arthur Andrew, 'The Ferns,' 17 Thomas-st., Ashfield
1912		Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Glendowan,' Glenbrook, Blue Mountains. B.M.A. Building, 30 Elizabeth-st. (President 1899, 1908).
1909		Hammond, Walter L., B.Sc., High School, Broken Hill.
1916		Hardy, Victor Lawson, 6 Dudley-street, Coogee.

Elected.

1905 P 3 Harker, George, D.Sc., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.

1913 P 1 Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.

1919 Harrison, Launcelot, B.A. *Cantab.*, B.Sc, *Syd.*, Professor of Zoology in the University of Sydney.

1923 Harrison, Travis Henry, Lecturer in Entomology and Botany at the Hawkesbury Agricultural College, Richmond.

1918 Hassan, Alex. Richard Roby, c/o W. Angliss & Co. Ppty. Ltd., 64 West Smithfield, London, E.C.

1919 Hay, Alexander, Coolangatta, N.S.W.

1916 Hay Dalrymple-, Richard T., L.S., Chief Commissioner of Forests, N. S. Wales; p.r. Goodchap Road, Chatswood.

1914 Hector, Alex. Burnet, 481 Kent-street.

1891 P 4 Hedley, Charles, F.L.S., Australian Museum, Sydney. (President 1914.)

1916 Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.

1919 Henriques, Frederick Lester, 56 Clarence-street.

1919 P 2 Henry, Max, D.S.O., B.V.Sc, M.R.C.V.S., 'Coram Cottage,' Essex-street, Epping.

1884 P 1 Henson, Joshua B., ASSOC. M. INST. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.

1918 Hindmarsh, Percival, M.A., B.Sc. (Agr.), Teachers' College, The University, Sydney; p.r. 'Lurnea,' Canbarra Avenue, Greenwich.

1921 P 1 Hindmarsh, William Lloyd, B.V.Sc., M.R.C.V.S., D.V.H., Stock Branch, Department of Agriculture, Sydney.

1916 Hoggan, Henry James, A.M.I.M.E., A M.I.E. (Aust.). Manchester Unity Chambers, 160 Castlereagh-street; p r. 'Lincluden,' Frederick-street, Rockdale.

1924 Holme, Ernest Rudolph, O.B.E., M.A., Professor of English Language in the University of Sydney.

1901 Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.

1905 P 3 Hooper, George, F.T.C. *Syd.*, Assistant Superintendent, Sydney Technical College; p.r. 'Nycumbene,' Nielson Park, Vaucluse.

1920 Hordern, Anthony, c/o Messrs. A. Hordern & Sons Ltd., Brickfield Hill.

1919 Horsfall, William Nichols, M.B., B.S. *Melb.*, Lecturer and Demonstrator in Physiology in the University of Sydney.

1919 Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.

1919 Hoskins, Cecil Harold, Windarra, Bowenfels.

1919 Houston, Ralph Liddle, 'Noorong,' Cooper-street, Strathfield.

1906 Howle, Walter Cresswell, L.S.A. *Lond.*, 215 Macquarie-street.

1913 Hudson, G. Inglis, J.P., F.C.S., 'Gudvangen,' Arden-st., Coogee.

1920 Hulle, Edward William, Commonwealth Bank of Australia.

1923 P 2 Hynes, Harold John, B.Sc., (Agr.), Walter and Eliza Hall Agricultural Research Fellow, Agricultural School, The University of Sydney.

1923 Ingram, William Wilson, M.C., M.D., Ch.B., The University, Sydney.

Elected		
1921		Jackson, Frederick Henry, B.E. *Syd.*, M.A.I.M.E., 40 King-street.
1922		Jacobs, Ernest Godfried, 'Cambria,' 106 Bland-street, Ashfield.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines, Sydney.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1918		Johns, Morgan Jones, A.M.I.E.E. *Lond.*, M.I.E. *Aust.*, M.I.M. *Aust.*, Box 2, P.O., Mount Morgan, Queensland.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., C.M.Z.S., Professor of Zoology in the University of Adelaide.
1924		Jones, Leo Joseph, Geological Surveyor, Department of Mines, Sydney.
1911		Julius, George A., B.Sc., M.E., M. I. MECH. E., Culwulla Chambers, Castlereagh-street, Sydney.
1876	P 4	Keele, Thomas William, L.S., M.INST.C.E., 'Gladsmuir,' Rivers-street, Woollahra.
1924		Kenner, James, Ph.D., D.Sc., F.R.S., Professor of Organic Chemistry in the University of Sydney.
1924		Kenny, Edward Joseph, Field Assistant, Department of Mines, Sydney; p r. 45 Robert-street, Marrickville.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, 58 Pitt-st.
1919	P 1	Kesteven, Hereward Leighton, M.D., Ch.M., D.Sc., Bulladelah, New South Wales.
1901		Kidd, Hector, M. INST. C.E., M. I. MECH. E., Cremorne Road, Cremorne.
1896		King, Kelso, 14 Martin Place.
1923		Kinghorn, James Roy, Australian Museum, Sydney.
1920		Kirchner, William John, B.Sc, 18 Edward-street, Concord.
1919		Kirk, Robert Newby, 25 O'Connell-street.
1881	P 23	Knibbs, Sir George, Kt., C.M.G., F.S.S., F R.A.S., L.S., Director, Commonwealth Institute of Science and Industry, Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild, 314 Albert-street, East Melbourne; p.r. 'Cooyal,' Sunnyside Avenue, Camberwell, Victoria. (President 1898).
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1911	P 3	Laseron, Charles Francis, Technological Museum.
1924		Leech, Thomas David James, B.Sc. *Syd.*, 'Orontes,' Clarke-st., Granville.
1920		Le Souef, Albert Sherbourne, Taronga Park, Mosman.
1916		L'Estrange, Walter William, 7 Church-street, Ashfield.
1909		Leverrier, Frank, B.A., B.Sc, K.C., 182 Phillip-street.
1883		Lingen, J. T., M.A. *Cantab.*, K.C., University Chambers, 167 Phillip-street, Sydney.
1923		Lipscomb, Alan Price, L.S., c/o Land Board Office, Goulburn.
1906		Loney, Charles Augustus Luxton, M. AM. SOC. REFR. E., Equitable Building, George-street.
1924		Love, David Horace, Beauchamp Avenue, Chatswood.

Elected		
1884		MacCormick, Sir Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.
1887		MacCulloch, Stanhope H., M.B., Ch.M. *Edin.*, 26 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co., Ld., Hunter-street, Sydney.
1922		MacKay, Alexander Clarke, c/o British Consul, Harbin, Manchuria.
1923		Mackay, Iven Giffard, C.M.G., D.S.O., B.A., Student Adviser and Secretary of Appointments Board, The University, Sydney.
1921		McDonald, Alexander Hugh Earle, Department of Agriculture, Sydney.
1903		McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st; p.r. 'Lowlands,' William-street, Double Bay,
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.S. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1919		McGeachie, Duncan, M.I.M.E., M.I.E. (Aust.), M.I.M M. (Aust.), 'Craig Royston,' Toronto, Lake Macquarie.
1906		McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., M. INST. C.E., Commissioner, Sydney Harbour Trust, Circular Quay.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. INST. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.
1922		McLuckie, John, M.A., B.Sc., (*Glasgow*), D.Sc., (*Syd.*), Lecturer in Botany in the University of Sydney.
1901	P 1	McMaster, Colin J., L.S., 'Crona,' Keydon Avenue, Warrawee.
1916		McQuiggin, Harold G., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.
1909		Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.
1883	P 44	Maiden, J. Henry, J.P., I.S.O., F.R.S., F.L.S., F.R.H.S., Hon. Fellow Roy. Soc. S.A.; Hon. Memb. Roy. Soc, W.A.; Netherlands Soc. for Promotion of Industry; Philadelphia College Pharm.; Southern Californian Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Society Great Britain; Bot. Soc. Edin.; Soc. Nat. de Agricultura (Chile); Soc. d'Horticulture d'Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas.; Roy. Soc. Queensl.; Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplomé of the Société Nationale d'Acclimatation de France; Linnean Medallist, Linnean Society; N.S.W. Govt. Rep. of the "Commission Consultative pour la Protection Internat. de la Nature"; Corr. Memb. National Acclimatisation Society of France; p.r. 'Levenshulme,' Turramurra Avenue, Turramurra. (President 1896, 1911.)
1924		Mance, Frederick Stapleton, Under Secretary for Mines, Mines Department Sydney; p.r. 'Binbah,' Lucretia Avenue, Longueville.
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1924		Mann, Arthur James, M.A. *Oxon.*, Headmaster, Tudor House School, Moss Vale.
1920	P 1	Mann, Cecil William, 'Pentreath,' Fairview-street, Arncliffe.
1920		Mann, James Elliott Furneaux, Barrister at Law, 163 Phillip-street.

Elected		
1908		Marshall, Frank, C.M.G., B.D.S., 151 Macquarie-street.
1914		Martin, A. H., Technical College, Sydney.
1912		Meldrum, Henry John, p.r. 'Craig Roy,' Sydney Rd., Manly.
1922		Mills, Arthur Edward, M.B., Ch.M., Dean of the Faculty of Medicine, Professor of Medicine in the University of Sydney, 139 Macquarie-street.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Union Club, Sydney.
1921		Morris, Albert, 74 Cornish-street, Railway Town, Broken Hill.
1922	P 7	Morrison, Frank Richard, Assistant Chemist, Technological Museum, Sydney; p.r. Brae-street, Waverley.
1924		Morrison, Malcolm, Department of Mines, Sydney.
1924		Mullens, Arnold Philip, Redmyre Road, Strathfield.
1924		Mullens, Arthur Launcelot, 13 Woodside Avenue, Strathfield.
1879		Mullins, John Lane, M.A. *Syd.*, M.L.C., 'Killountan,' Double Bay.
1915		Murphy, R. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry, Technical College, Sydney.
1923	P 2	Murray, Jack Keith, B.A., B.Sc. (Agr.), Principal, Queensland Agricultural College, Gatton, Queensland.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; p.r. 'St. Elmo,' Tupper-st., Marrickville. (President 1920.) *Vice-President.*
1917		Nash, Norman C., 'Ruanora,' Lucas Road, Burwood,
1924		Nickoll, Harvey, L.R.C.P., L.R.C.S., Barham, via Mudgee, N.S.W.
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1920		Noble, Robert Jackson, M.Sc., B.Sc., (Agr.), Ph.D., 'Lyndon,' Carrington-street, Homebush.
1919		Oakden, Frank, C.E., 33 Hunter-street.
1903		‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1921		Olding, George Henry, 4 Bayswater Road, Drummoyne.
1913		Ollé, A. D., F.C.S., 'Kareema,' Charlotte-street, Ashfield.
1896		Onslow, Col. James William Macarthur, B.A., LL.B., 'Gilbulla,' Menangle.
1917		Ormsby, Irwin, 'Caleula,' Allison Road, Randwick.
1891		Osborn, A. F., ASSOC. M. INST. C.E., Water Supply Branch, Sydney, 'Uplands,' Meadow Bank, N.S.W.
1921	P 2	Osborne, George Davenport, B.Sc., Demonstrator in Geology in the University of Sydney; p.r. 'Belle-Vue,' Kembla-st., Arncliffe.
1920		Paine, William Horace, State Abattoirs, Homebush Bay, N.S.W.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1921		Parkes, Varney, Royal Chambers, Castlereagh-street.
1920	P 27	Penfold, Arthur Ramon, F.C.S., Economic Chemist, Technological Museum, Harris-street, Ultimo.

Elected		
1918		Petrie, James Matthew, D.Sc., F.I.C., Research Fellow of the Linnean Society in Biochemistry, The University, Sydney.
1909	P 2	Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, Director of the Seismological Observatory, St. Ignatius'College, Riverview.
1879	P 8	Pittman, Edward F., ASSOC. R.S.M., L.S., 'St. Ives,' Toorak Road, South Yarra, Melbourne.
1881		Poate, Frederick, F.R.A.S., L.S., 'Clanfield,' 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, M.B., Ch. M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.
1917		Poole, William, M.E., (Civil, Min. and Met.) *Syd.*, M. INST. C.E., M.I.M.M., M.I.E., Aust., M.Am. I.M.E., M. Aust. I. M.M., L.S., 906 Culwulla Chambers, Castlereagh-street.
1896		Pope, Roland James, B.A., *Syd.*, M.D., C.M., F.R.C.S., *Edin.*, 185 Macquarie-street.
1910		Potts, Henry William, F.L.S., F.C.S., c/o Lindley Walker & Co., Ltd., Mark Lane, Sussex-street, Sydney.
1921	P 2	Powell, Charles Wilfrid Roberts, A.I.C., c/o Colonial Sugar Refining Co., O'Connell-street.
1918		Powell, John, 170-2 Palmer-street.
1918		Priestley, Henry, M.D., Ch. M., B.Sc., Associate-Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 193 Macquarie-street.
1912	P 2	Radcliff, Sidney, F.C.S., Department of Chemistry, The University of Sydney.
1922		Raggatt, Harold George, B.Sc., Lord-street, Roseville.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1923		Reid, Cicero Augustus, c/o McDiarmid & Co., 202 Latrobe-st., Melbourne.
1909		Reid, David, 'Holmsdale,' Pymble.
1914		Rhodes, Thomas, 'High Coombe,' Carlingford.
1920		Richardson, John James, A.M.I.E.E. *Lond.*, 'Kurrawyba,' Upper Spit Road, Mosman.
1921		Robertson, Frederick Arnold, Science Master, Sydney C. of E. Grammar School, North Sydney.
1924		Robertson, James R. M., M.D., C.M., F.R.G.S., F.G.S., 'Vanduara,' Ellamang Avenue, Kirribilli.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 225 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1897		Russell, Harry Ambrose, B.A., c/o Sly and Russell, 369 George-street; p.r. 'Mahuru,' Park Road, Bowral.
1907		Ryder, Charles Dudley, Box 1934 G.P.O. Sydney.
1922		Sandy, Harold Arthur Montague, 326 George-street.
1917		Sawkins, Dansie T., M.A., 'Brymedura,' Kissing Point Road, Turramurra.
1920		Sawyer, Basil, B.E., 'Birri Birra,' The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc., *Syd.*, 18 Middle Head Road, Mosman.

Elected		
1913		Scammell, W. J., Mem. Pharm. Soc. *Grt. Brit.*, 18 Middle Head Road, Mosman.
1919		Sear, Walter George Lane, c/o J. Kitchen & Sons, Ingles-st., Port Melbourne.
1923		Seddon, Herbert Robert, D.V.Sc., Director, Veterinary Research Station, Glenfield.
1921		Sellers, Alfred Edward Oswald, M.I.M.E., M.A.I.E., 'Strathmere,' Bellambi.
1904		Sellors, Richard P., B.A. *Syd.*, 'Mayfield,' Wentworthville.
1918	P 1	Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., Cathcart House, Castlereagh-street.
1924		Shelton, James Peel, M.Sc., B.Sc Agr., Department of Agriculture, Sydney.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1910		Simpson, William Walker, 'Abbotsford,' Leichhardt-street, Waverley.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. 'Broomage,' Kangaroo-street, Manly.
1916		Smith, Stephen Henry, Under Secretary and Director of Education, Department of Education, Sydney.
1922	P 1	Smith, Thomas Hodge, Australian Museum, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, Daily Telegraph Building, King-st.
1916		Stephen, Alfred Ernest, F.C.S., 801 Culwulla Chambers, 67 Castlereagh-street, Sydney.
1921		Stephen, Henry Montague, B.A., LL.B., 167 Phillip-street.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 13 Dover Road, Rose Bay.
1920	P 1	Stephens, John Gower, M.B., Royal Prince Alfred Hospital, Camperdown.
1913		Stewart, Alex. Hay, B.E., 165 Wardell Road, Dulwich Hill.
1900		Stewart, J Douglas, B.V.Sc., M.R.C.V S., Professor of Veterinary Science in the University of Sydney; 'Berelle,' Homebush Road, Strathfield.
1909		Stokes, Edward Sutherland, M.B. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1919		Stroud, Sydney Hartnett, F.I.C., Lecturer in Pharmacy in the University of Sydney.
1918		Sullivan, Herbert Jay, c/o Lewis Berger and Sons (Aust.) Ltd., Rhodes.
1920		Sulman, Sir John, Kt., Warrung-st., McMahon's Point, North Sydney.
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road, Alexandria.
1901	P 10	Sussmilch, C. A., F.G.S., Principal of the Technical College, Newcastle, N.S.W. (President 1922.)
1919		Sutherland, George Fife, A.R.C.Sc., *Lond.*, Assistant-Professor in Mechanical Engineering, in the University of Sydney.

Elected		
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb.*, B.Sc. *Oxon.*, 'Lynton,' Kent Road, Rose Bay.
1919		Swain, Herbert John, B.A. *Cantab.*, B.Sc., B.E. *Syd.*, Lecturer in Mechanical Engineering, Technical College, Sydney.
1915	P 2	Taylor, Harold B., B.Sc., Kenneth-street, Longueville.
1893		‡Taylor, James, B.Sc., A.R.S.M. 'Cartref,' Brierly-st., Mosman.
1921	P 2	Taylor, John Kingsley, Hawkesbury Agricultural College, Richmond; p.r. 16 Ferrier-street, Rockdale.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1921	P 3	Taylor, Thomas Griffith, B.A., D.Sc., B.E., Associate-Professor of Geography in the University of Sydney.
1920		Tebbutt, Arthur Hamilton, B.A., M.B., D.P.H., 185 Macquarie-st.
1899		Teece, R., F.I.A., F.F.A., Wolseley Road, Point Piper.
1923		Thomas, David, B.E., M.I.M.M., F.G.S., 15 Clifton Avenue, Burwood.
1878		Thomas, F. J., 'Lovat,' Nelson-street, Woollahra.
1919		Thomas, John, L.S., Chief Mining Surveyor, Mines Department Sydney; p.r. 'Remeura,' Pine and Harrow Roads, Auburn.
1924		Thompson, Herbert William, 'Marathon,' Francis-st, Randwick
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-st.
1919		Thorne, Harold Henry, B.A. *Cantab.*, B.Sc. *Syd.*, Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1916		Tilley, Cecil E., D.Sc., The Sedgwick Museum, Emmanuel College, Cambridge, England.
1916		Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S., Biological Branch, Cawthron Institute, Nelson, New Zealand.
1923		Timcke, Edward Waldemar, Meteorologist, Weather Bureau, Sydney.
1923		Tindale, Harold, Works Engineer, c/o Australian Gas-Light Co., Mortlake.
1923		Toppin, Richmond Douglas, A.I.C., Parke Davis & Co., Roseberry.
1879		Trebeck, P. C., 'Banavie,' Bowral.
1900		Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.
1919	P 4	Turner, Eustace Ebenezer, B.A. *Cantab.*, D.Sc. *Lond.*, A.I.C., East London College, Mile End Road, London, E. I.
1916		Valder, George, J.P., Under Secretary and Director, Department of Agriculture, Sydney.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 78 Pitt-street.
1903	P 5	Vonwiller, Oscar U., B.Sc., Professor of Physics in the University of Sydney. ***Hon. Secretary.***
1924		Wade, Rev. Robert Thompson, M.A., Headfort School, Killara.
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.

Elected		
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1919	P 1	Walkom, Arthur Bache, D.Sc., Macleay House, 16 College-st.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust.; George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Syd.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1918		Ward, Edward Naunton, Curator of the Botanic Gardens, Syd.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1922		Wark, Blair Anderson, V.C., D.S.O., M.I.Q.C., c/o Thompson and Wark, T. & G. Building, Elizabeth-street; p r. 'Braeside,' Zeta-street, Lane Cove, Sydney.
1883	P 17	Warren, W. H., LL.D., WH. SC., M. INST. C.E., M. AM. SOC. C.E., Member of Council of the International Assoc. for Testing Materials, Professor of Engineering in the University of Sydney. (President 1892, 1902.)
1921		‡Waterhouse, G. Athol, D.Sc., B.E., F.E.S., Royal Mint, Macquarie-street. *Hon. Secretary.*
1924		Waterhouse, Leslie Vickery, B E. *Syd.*, 58 Pitt-street.
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 2	Waterhouse, Walter L., M.C., B.Sc. (*Agr.*), 'Cairnleith,' Archer-street, Chatswood.
1919		Watkin-Brown, Willie Thomas, F.R.M.S., 24 Brown's Road, Kogarah.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, University Club, Castlereagh-street.
1910		Watson, James Frederick, M.B., Ch M., 'Midhurst,' Woollahra.
1911		Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney.
1920	P 11	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum.
1907	P 1	Welch, William, F.R.G S., 'Roto-iti,' Boyle-street, Mosman.
1920	P 1	Wellish, Edward Montague, M.A., Lecturer in Applied Mathematics in the University of Sydney.
1921		Wenholz, Harold, 29 Palace-street, Petersham.
1881		‡Wesley, W. H., London.
1922		Whibley, Harry Clement, 39 Moore-street, Leichhardt.
1909	P 3	White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College.
1918		White, Edmond Aunger, M.A.I.M.E., c/o Electrolytic Refining and Smelting Co. of Australia Ltd., Port Kembla, N.S.W.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1923		Whitehouse, Frank, B.V.Sc, (Syd.) 'Dane Bank,' Albyn Road, Strathfield.
1921		Willan, Thomas Lindsay, B.Sc., Geological Survey, Department of Mines, Sydney.
1920		Williams, Harry, A.I.C., c/o Rosebery Lanolines Pty. Ltd., Arlington Mills, Botany.
1924		Williams, William John, 5 Effingham-street, Mosman.
1917		Willington, William Thos., O.B.E., King-street, Arncliffe.

Elected.		
1923		Wilson, Stanley Eric, 'Chatham,' James-street, Manly.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 9	Woolnough, Walter George, D.Sc., F.G.S., Florence-st., Killara.
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, 184 Sussex-street.
1916		Youll, John Gibson, Water Conservation and Irrigation Commission, Leeton, N.S.W.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1914		Bateson, W. H., M.A., F.R.S., Director of the John Innes Horticultural Institution, England, The Manor House, Merton, Surrey, England.
1918		Chilton, Charles, M.A., D.Sc., M.B., C.M. etc., Professor of Biology, Canterbury College, Christchurch, N.Z.
1914		Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. ENG., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 5'	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, 'Fieldhead,' George Road, Coombe Warren, Kingston. Surrey, England. (President 1889, 1900.)
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia.
1912		Martin, C. J., C.M.G., D.Sc., F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London, S.W.I.
1894		Spencer, Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., Emeritus Professor of Biology in the University of Melbourne.
1900		Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL D., Sc D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.
1921		Threlfall, Sir Richard, K.B.E., M.A., F.R.S., lately Professor of Physics in the University of Sydney, 'Oakhurst,' Church Road, Edgbaston, Birmingham, England.
1922		Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge, England.

* Retains the rights of ordinary membership. Elected 1872.

Obituary 1924-25.

Honorary Member.

Hemsley, W. Botting (Elected 1911)

Ordinary Members.

Elected.		Elected.	
1877	Abbott, William Edward	1891	Houghton, Thomas Harry
1894	Baxter, William Howe	1923	Hunter, John Irvine
1902	Faithfull, William Percy	1883	Kater, Henry Edward
1881	Furber, Thomas Frederick	1893	Smith, Henry George
1884	Haswell, William Aitcheson	1903	Stoddart, Alfred George

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.,
Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded
1878 *Professor Sir Richard Owen, K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1886 *Professor L. G. De Koninck, M.D.
1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc. D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 *Robert Logan Jack, LL.D., F.G.S., F.R.G.S.
1895 *Robert Etheridge, Jnr.
1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.
1900 *Sir John Murray, K.C.B., LL.D., Sc.D., F.R.S.
1901 *Edward John Eyre.
1902 *F. Manson Bailey, C.M.G., F.L.S.
1903 *Alfred William Howitt, D.Sc., F.G.S.
1907 Walter Howchin, F.G.S., University of Adelaide.
1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.
1912 *W. H. Twelvetrees, F.G.S.
1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.
1915 *Professor W. A. Haswell, M.A., D.Sc., F.R.S.
1917 Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., The University, Sydney.
1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.
1920 *Joseph Edmund Carne, F.G.S.
1921 Joseph James Fletcher, M.A., B.Sc., 'Ravenscourt,' Woolwich.
1922 Richard Thomas Baker, The Avenue, Cheltenham.
1923 Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc., F.R.S., National Museum, Melbourne.
1924 Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P., 'Levenshulme,' Turramurra Avenue, Turramurra.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By R. H. Cambage, F.L.S.

Delivered to the Royal Society of N.S.W. and broadcasted on May 7, 1924.*

The Society's efforts have again been rewarded by a successful year, and our roll of membership now stands at 375.

In addition to the papers read at the general monthly meetings, the following popular science lectures were given, namely:—"Some Wonders of the Australian Flora," by R. T. Baker; "Historical and Modern Practice of Quarantine," by J. H. L. Cumpston, M.D., D.P.H.; "Some Industrial Achievements of Organic Chemistry," by Acting-Professor G. Harker, D.Sc.; "Some Ancient Volcanoes of Australia," by Assist. Professor W. R. Browne, D.Sc.

Successful meetings were held throughout the Session by the Sections of Geology, Agriculture and Industry.

The Council has awarded the Clarke Memorial Medal to Mr. J. H. Maiden, I.S.O., F.R.S., F.L.S., in recognition of his highly meritorious contributions to the Botany of Australia, and particularly of his monumental work on the genus *Eucalyptus*, as well as his very eminent services in the advancement of natural science in Australia. No one has given more of his best efforts to Australian science

***This is the first occasion on which an Address has been broadcasted from a Scientific Society in Australia.—(Editors).**

in general, or to this Society in particular, than Mr. Maiden.

It is a pleasure to record that the following members have been honoured during the year:—

Sir George Knibbs, Knight Bachelor.

Sir Hugh Denison, Knight Commander of the British Empire.

Mr. Charles Hedley, Honorary Fellow of the New Zealand Institute.

Sir George Knibbs has now been a member of this Society for forty-three years, and is still actively engaged upon scientific work.

Mr. Hedley has recently resigned the position of Keeper of the Collections at the Australian Museum, and accepted an appointment as Scientific Director of the Great Barrier Reef Committee, and he carries with him our very best wishes for the success of the important work about to be undertaken.

I desire to record the Society's great appreciation of the assistance rendered throughout the year by the Honorary Secretaries, Professor O. U. Vonwiller and Mr. G. A. Waterhouse, also the Honorary Treasurer, Professor H. G. Chapman, all of whom have contributed much towards making the session a success.

OBITUARY.

It is with regret I have to announce that during the year we have lost by death a Vice-Patron and seven ordinary members.

Sir Walter Edward Davidson, K.C.M.G., Governor of the State of New South Wales from February, 1918, and a Vice-Patron of this Society, died at Government House,

Sydney, on the 16th September, 1923, and was buried at South Head Cemetery. He was born at Valetta, Malta, on April 20, 1859, and was a son of the late James Davidson, of Killyleagh, County Down, Ireland. A scholar and exhibitioner of Christ's College, Cambridge, he entered the Ceylon Civil Service in 1880 as a writer, and remained there for nearly 20 years. He was secretary to the Ceylon Commission and to the Colonial and Indian Exhibition in 1886, and chairman of the municipal council and Mayor of Colombo in 1898, also Ceylon Commissioner at the Paris Exhibition in 1900. In 1901 he went to the Transvaal as assistant secretary to the Administrator, and the following year was made a C.M.G., and appointed Colonial Secretary. In 1904 he was appointed Governor of Seychelles Islands, and in October, 1912, his appointment as Governor of Newfoundland was announced. He was a Knight of Grace of St. John of Jerusalem, and was created K.C.M.G. in 1914.

Sir Walter Davidson had been twice married. He was first married in 1882 to a daughter of the late Dr. John Baber, of Thurlow-square, London, and there was one son of the marriage. His second marriage took place in 1907, to Margaret Agnes, youngest daughter of the late General the Hon. Sir Percy Fielding, and there are two daughters of that marriage. Sir Walter Davidson wrote two books on Ceylon and its resources; in 1886 he wrote a book for the Colonial and Indian Exhibition, and in 1900 he wrote one for the Paris Exhibition. In 1909 he published a volume of "Archives of Seychelles prior to 1810."

Having a large grasp of public questions in their broadest aspects, Sir Walter Davidson was able to handle difficult problems connected with his duties, with a high degree of success, and being possessed of a sympathetic

nature, as well as a strict sense of justice, he soon won popularity as Governor of this State, and by getting into touch with all sections of the community, he endeared himself in a remarkable degree to the people of New South Wales.

Sir Walter Davidson was much interested in the work of science. He attended and spoke in an appreciative manner at the meeting of this Society held on 7th December, 1921, which was specially devoted to commemorating the formation, in 1821, of the Philosophical Society of Australasia, the first scientific Society in Australia, and the forerunner of the Royal Society of New South Wales.

He opened the Sydney session of the Pan-Pacific Science Congress on the 24th August, 1923, and delivered an inspiring address He also provided a welcome for the visiting scientists by a Reception at Government House, and his last public act was to preside over Professor H. E. Gregory's lecture at the Town Hall, when the state of his health might well have furnished just cause for his deciding not to be present.

HENRY DEANE was born at Clapham, London, on 26th March, 1847, and was educated at Queen's College, Galway, and King's College, London, obtaining his M.A. degree at Queen's University of Ireland, and Sydney (*ad eundem*). He was first engaged in connection with the London metropolitan railways, and later was employed in Hungary and in the Philippine Islands on similar work. Coming to Australia, he joined the New South Wales Railway Construction Department in February, 1880, and eventually rose to the position of Engineer-in-Chief, in which capacity he was associated with many important engineering works, including the Hawkesbury River Bridge

and the introduction of tramways. He was twice sent abroad from the New South Wales service to report on the latest engineering developments.

In 1906 Mr. Deane retired from the service of this State, and accepted an appointment with the Commonwealth Oil Corporation, taking charge of the construction of the railway from the main western line on the Blue Mountains at Newnes Junction to the Wolgan River, where the oil-shale mine was then being established at Newnes. He introduced special engines, called "Shay locomotives," capable of negotiating the exceedingly steep grades and sharp curves on portion of this line. In 1908, Mr. Deane, who had previously been associated with the proposed East-West railway, was engaged by the Commonwealth Government as controlling and consulting engineer in connection with the survey of the transcontinental railway between Port Augusta and Kalgoorlie, and when the Commonwealth railway construction branch was formed in 1910, he was appointed Engineer-in-Chief in charge of the department. Mr. Deane built a considerable portion of the East-West Railway, meeting with many difficulties in taking a line about 1100 miles through an almost waterless and uninhabited region. He severed his connection with the Commonwealth railways in 1914, and since then practised in Melbourne as a consulting engineer.

Mr. Deane was well known to those connected with scientific institutions throughout Australia, and was a member of this Society for 39 years, having joined in 1885. He was first elected a member of the Council in 1890, and was President in 1897 and again in 1907. In 1894 he was President of the Institution of Surveyors of New South Wales. He was President of the Linnean Society of New South Wales in 1895, and also in 1896.

He was a Member of the Institute of Civil Engineers, a Fellow of the Royal Meteorological Society, a Fellow of the Linnean Society of London, and a Fellow of the Royal Horticultural Society. He was a great lover of horticulture, and a keen student of Botany and Palæontology; also a recognised authority on the Tertiary flora of Australia, to which subject he made valuable contributions. His interest in the genus *Eucalyptus,* inspired and stimulated by his early association with the late Rev. Dr. William Woolls, is evidenced by his many writings on this interesting group of trees, much of his work having been published in the Proceedings of the Linnean Society of New South Wales in collaboration with Mr. J. H. Maiden. As late as August, 1923, Mr. Deane attended the Melbourne session of the Pan-Pacific Science Congress, and took considerable interest in the Forestry section.

Mr. Deane possessed a natural, unassuming character, embodying gentleness, integrity, and wisdom, which at all times called forth our affection and our admiration, and his absence from our future scientific assemblages will be greatly felt by many of his confrères. He died at Malvern, near Melbourne, on the 12th March, 1924, at the age of 77, and was buried in the Brighton cemetery. He is survived by a widow, three sons, and four daughters.

Dr. Jacob Robert L. Dixon was born on the 16th October, 1861, at Liverpool, England, and was educated at the Royal Infirmary Medical School, Liverpool. He was silver medallist in Medicine, Surgery, Pathology and Obstetrics in his third year subjects in 1882, and in 1884 obtained the degrees of L.R.C.P., Edin., and M.R.C.S., England. In his early days he was Hon. Pathologist to the Royal Southern Hospital, Liverpool, and for many years was in private practice in the South of England, coming to

Australia from Torquay in 1912. For a few weeks he carried on at Newcastle the Port work of Dr. L'Strange Eames, but very soon was appointed Demonstrator in Physiology at the Sydney University, and somewhat recently received the appointment of Lecturer in Micro-Histology. His knowledge of microscopy was of a high order, and he had a great love for natural history.

Dr. Dixon joined the Royal Society in 1916, and died on the 27th October, 1923, leaving a widow. He was buried in the Northern Suburbs Cemetery.

Ernest Brougham Docker was born at Thornthwaite, near Scone, New South Wales, in April, 1842. He was a son of the late Joseph Docker, M.L.C., and was educated at the Collegiate School, Cook's River, and the Sydney University, where he had a brilliant career. He won the Denison Scholarship at St. Paul's College in 1860. The following year he took the University medal for English verse, and in 1862 won the Wentworth medal for English essay. He took his B.A. degree in 1863, and his M.A. degree two years later.

Judge Docker was called to the New South Wales Bar in 1867, and was appointed Crown Prosecutor in 1875. He was elevated to the position of District Court Judge of the north-western district in 1884, carrying out the duties of the latter position until 1912, when he was appointed Judge of the Metropolitan District Court. In 1894 he was appointed Judge to hold a Court at Norfolk Island. He retired from the District Court Bench in 1918. His death took place at Elizabeth Bay on the 12th August, 1923, and he was buried at South Head Cemetery.

Judge Docker was a member of the Council of the King's School, of the Church of England Synod of the

Sydney diocese, and of the Bathurst diocese, also of the Royal Australian Historical Society and of the Photographic Society of New South Wales, of which latter Society he was President from 1894 to 1907. He was one of the oldest and most beloved members of our Society, and, having been elected in 1876, his membership extended over a period of 47 years. He was also one of the most regular attendants at the general monthly meetings, and frequently at those of the Section of Geology, and was with us almost up to the time of his death. He was in the very front rank of amateur photographers in this State, and was always ready to allow the fullest use to be made of his beautiful pictures and lantern slides, which have contributed towards the success of many an address given by members of this Society. He was always delighted when his art as a photographer could be utilised to illustrate and illuminate some point of natural science. His was a personality which at all times commanded our affection and respect.

Judge Docker's wife. who was a daughter of the late Archdeacon Tucker, predeceased him, having died in June, 1918. He is survived by two sons and seven daughters.

James Henderson was born on the 20th June, 1850, near Inverkeithney, Banffshire, where his family for generations had been farmers. He was educated at a school in Aberdeenshire, and at the age of 17 was apprenticed to Messrs. J. and J. Crombie, proprietors of the Granholm Mills, Aberdeen. He became secretary, and later vice-president, of the Glasgow Shorthand Writers' Association. In 1870 Mr. Henderson entered the counting-house of Mr. T. R. Johnstone, a Glasgow merchant, and became cashier within two years. After occupying this position for six years he was advised, for health reasons, to leave for Australia.

Mr. Henderson left Scotland in 1878 by the R.M.S. *Chimborazo*, which vessel went ashore near Jervis Bay, and was wrecked, though all the passengers were rescued. He soon secured a position in Sydney with the Bank of New South Wales, and three years later joined the English, Scottish and Australian Bank, and was accountant when, in 1887, the position of assistant manager of the City Bank of Sydney was offered to and accepted by him. Ten years later he was appointed general manager, which position he filled with distinction until his retirement at the end of 1916. He died on the 18th July, 1923, and was buried at the Field of Mars Cemetery.

Mr. Henderson was a Fellow of the Royal Economic Society, and nearly 40 years ago he contributed to the "Sydney Morning Herald," a series of articles on "Land and Currency," and later, another series on "Early Colonial Banks." Many papers were read by him before the Australian Economic Association, and the Bankers' Institute of New South Wales, of which latter organisation he was vice-president at one period. He was a member of the Royal Society of New South Wales for 24 years, having joined in 1899. In his early days he was an excellent horseman, and always took a practical interest in sport. He is survived by his widow, who was a daughter of the late Mr. R. P. Richardson, two sons, and two daughters. Another son was killed on active service.

William Edmund Kemp was born at Newtown, near Sydney, on 12th June, 1858, and was a son of the late Mr. W. E. Kemp, at one time Architect for Public Schools.

He entered the Public Works Department on the 1st June, 1875, and was appointed Engineering Assistant in 1878, and Resident Engineer in 1884. Between the years 1884 and 1897, Mr. Kemp was engaged principally in con-

nection with the Newcastle Harbour Works, Hunter River District Water Supply, including the towns of Maitland and Newcastle, the Lake Macquarie Harbour Works and Manning River Entrance. In 1898, he was appointed assistant to the late Mr. L. A. B. Wade, in connection with the water supply to the country towns of the State. During most of the period from 1899 to 1912, Mr. Kemp was in charge of the Harbour Works at the Richmond and Clarence River Entrances. He was also some years District Works Officer in charge of the Lismore District. In 1915 he was appointed Resident Engineer-in-Charge of the Coff's Harbour Improvement Works under Messrs. Norton Griffiths Ltd., and when the works came back to the control of the Department, Mr. Kemp retained his position as Engineer-in-Charge of their construction until the time of his death.

He was elected an Associate Member of the Institute of Civil Engineers in 1889, and a member of the Royal Society of New South Wales in 1914.

Mr. Kemp's long experience in engineering matters both as regards Water Supply and Harbour Works, and his sound judgment, made his services of very great value to the officers under whom he was placed. He died at Coff's Harbour on the 1st May, 1923, and was buried at the Gore Hill Cemetery, North Sydney.

ALFRED LEE was born near Dublin in 1858, and was taken to New Zealand at the age of four, his people having received a grant of land there. He came to Sydney when about 14 years old, and was for nearly fifty years connected with the firm of Enoch Taylor and Co., Australia and London, becoming a partner in 1888. He was a great reader, a keen horticulturalist, and a good sportsman, having indulged in cycling, football, tennis, golf and fish-

ing. For many years he devoted much time to collecting books on Australia, New Zealand, and the Pacific Islands, and these, which included some rare publications, were obtained from him by the late David Mitchell to add to the Mitchell Library collection.

Mr. Lee was a life member, and one of the founders of the Royal Australian Historical Society, and was a member of the Royal Society of New South Wales for seventeen years, having joined in 1906. He died at Glen Roona, Bondi, on the 2nd August, 1923, and was buried at the Waverley Cemetery. He leaves a widow, one son and three daughters.

JAMES EDWARD MILLER was a member of this Society for eighteen years, having been elected in 1905. He was born on the 23rd November, 1865, and joined the Police Service in 1885. He attained non-commissioned rank on the 1st April, 1892, and was made Acting Inspector on 1st July, 1909. At the time of his death he held the rank of Superintendent 1st Class. Since joining this Society he was stationed at Cobar, Walgett, Inverell, Broken Hill and Albury. Mr. Miller, who was a bachelor, died at Albury on the 23rd August, 1923.

PAN-PACIFIC SCIENCE CONGRESS.

To lovers of science, the event of the year was the holding of the second, or 1923, Pan-Pacific Science Congress at Melbourne and Sydney, in August last, the first Congress having been held at Honolulu in August, 1920. The holding of this most important meeting was made possible by the generosity of the Commonwealth and State Governments, and, of the latter, particularly those of New South Wales and Victoria, in which States the meetings were held. Most gratifying help, both financial and otherwise, was also furnished by many citizens in both Sydney and Mel-

bourne; in fact, the whole movement, which was under the auspices of the Australian National Research Council, was so heartily supported on all sides that it soon became evident the people of Australia had realised that a great compliment had been paid to the Commonwealth, in giving it control of the arrangements for such an important national event, and all wished to contribute towards its success. It was also made clear that the value of science, in its broadest sense, was fully recognised and appreciated. This whole-hearted support was most gratifying and helpful to those entrusted with arranging the details of the meetings.

The response from abroad was of an equally pleasing nature, and eighty distinguished overseas scientists were present at the Congress, worthily representing the various countries having interests within or bordering the Pacific. The representation was distributed as follows:—Great Britain, 12; United States of America, 17; Honolulu, 6; Philippines, 5; Japan and Formosa, 10; Netherlands and Dutch East India Government, 5; Canada, 3; New Zealand, 13; British Malaya, Fiji, Hongkong, India, New Guinea, Papua, and Tahiti, 9.

In addition to the important papers read by those present at the meetings, many valuable contributions were received from invited scientists who were unable to visit Australia.

At the Honolulu meeting in 1920, it was arranged that the subjects to be dealt with should include only those which had a definite bearing on Pacific problems, and such sciences as were regarded of world-wide application, without any special reference to the Pacific, were omitted. As a result of action taken at the 1923 Congress in Aus-

tralia, consideration is being given to the question of widening the scope of the subjects at future Pan-Pacific Science Congresses.

Matters dealt with at the Australian Congress embraced the following subjects:—Agriculture, Veterinary Science, Anthropology and Ethnology, Botany, Forestry, Entomology, Zoology, Geography and Oceanography, Geology, Hygiene, Geodesy and Geophysics, Pacific Radio Telegraphy, and Longitude by Wireless.

Some evidence of the importance with which this Congress was regarded by other countries, may be gauged from the fact that the United States of America sent the new scout cruiser "Milwaukee," equipped with the sonic depth finder, which took a new set of soundings on the voyage across the Pacific. The cruiser arrived with dramatic suddenness on the eve of the Sydney meeting, and her Commander, Captain W. W. Asserson, came as a delegate to the Congress from the United States Navy Department, and read a paper on the principle of construction and use of the sonic depth finder.

A feature of the Congress was the provision for discussions between sections having a common interest in a particular subject, though from a different point of view. These discussions proved of immense interest and of great value.

Popular science lectures, which were open to the public and attended by large audiences, were given by distinguished visitors, and the appreciation shown for these lectures was gratifying in the extreme.

At the final general meeting it was resolved:—

1. That this Congress recommends the establishment of a permanent organisation of the scientific institutions and

individuals engaged in research on the scientific problems of the Pacific region;

2. That the President of the Third Pan-Pacific Science Congress request the National Research Council or similar institution or agency of each of the following countries, viz.: Australia, Canada, Chile, France, Great Britain, Japan, Netherlands, New Zealand, the Philippine Islands and the United States of America, to appoint a member of an Organisation Committee, the Chairman of the Committee to be a resident of the country in which the Congress will be held, and that the Committee be empowered to add to its membership representatives from other Pacific countries.

It was arranged that the third Pan-Pacific Science Congress should be held in Japan in 1926, under the auspices of the National Research Council of Japan.

These congresses aim not only at the promotion of the study of scientific problems of common interest in the Pacific, but also at the maintenance of harmonious relations between all countries within and bordering the Pacific region. It is beyond question that the recent Congress was successful from the scientific point of view in advancing the knowledge of the Pacific, for no meeting such as this, composed of so many of the brightest intellects from overseas, could assemble and participate in an interchange of views without mutual benefit in the highest degree. The outstanding success, however, which was patent to every observant person throughout the Commonwealth, was the wonderful advance made in strengthening the harmonious relations between peoples widely scattered throughout the Pacific region. This work of promoting goodwill and maintaining the most friendly relations between residents of the Pacific is of paramount importance, and helps in the wider scheme of the great brotherhood of science, which aims, among other things, at assisting in cementing the bonds of peace between countries all over the world.

AUSTRALIAN RESOURCES OF LIQUID FUELS.

SYNOPSIS.

NEED FOR INVESTIGATION.

So far, no mineral oil has been discovered in Australia in commercial quantities, and having in view the vast importance to this country of such a commodity, it becomes desirable in the highest degree fully to investigate the possibilities of its existence within the Commonwealth, and to examine the sources where it is possibly conserved, or to find a suitable substitute.

The use of petroleum now enters so much into the activities surrounding our industrial lives, and is so vital in connection with matters relating to defence, that the questions, as to whether the world's supply from oil wells will continue for a lengthy period to meet future increasing demands, and, if not, whence a substitute is

to come, may very properly receive the fullest consideration. On all sides the substitution of liquid fuels for coal may be seen, and the likelihood of practically all the steamships of the immediate future adopting liquid fuel as a motive power is abundantly apparent.

In an address delivered to the National Oil Shale Conference, America, in 1923, Dr. Victor C. Alderson stated that, although the United States is the greatest oil-producing nation on earth, yielding two-thirds of the world's supply, yet the domestic demand for oil, in every one of its forms, is greater than the supply. He also said that if to the well oil is added the oil that may be derived from shale, that country may justly be regarded, from the point of view of fuel, as the most favoured nation on earth.*

Mineral oil, like gold, does not replenish itself once it is taken out of the earth, and although supplies may be sufficient for many years, it is impossible to forecast their actual duration.

It is difficult adequately to appreciate the extreme importance and value of a good supply of mineral oil to any country. In regard to the position in America, the following statement made in December, 1923, by Mr. H. C. Hoover, United States Secretary of Commerce, serves to illustrate the paramount importance of this question in that country. Mr. Hoover stated:—"As a result of a survey of our own and the world situation, it is evident that our domestic sources of oil will last only a generation at the present rate of exhaustion. Meanwhile, foreign nations are rapidly pre-empting the

*The Mining Congress Journal, Vol. 9, No. 10 (October, 1923). See also Quarterly of the Colorado School of Mines, Vol. 18, No. 4 (October, 1923).

available foreign oil-bearing territory. Unless our nationals re-enforce and increase their holdings abroad, we shall be dependent upon other nations for the supply of this vital commodity within a measurable number of years. The truth of the matter is that other countries have conserved their oil at the expense of our own. We must go to the foreign fields, and in a big way."*

This most candid exhortation to America to go abroad and secure all the oil it can, while conserving its own supplies, surely has a significance which should not be lost on Australia, and is a reminder that it is imperative that an investigation of a highly scientific and technical character should be undertaken forthwith into the whole of the possibilities of an Australian liquid fuel supply, so that, at least for defence purposes, the Commonwealth, if it is at all possible, may be self-contained in regard to this "vital commodity."

Of the world's oil production to date, North America has contributed upwards of 60 per cent. and Europe upwards of 30 per cent., and although the supply in the United States in 1923 was sufficient to meet its demands, yet at the present time, owing to the extension of the number of avenues for its use, and a slightly reduced output, the position has changed from one of surplus to one of sufficiency with prudence. The inflation of supplies in 1923 came from some important and valuable discoveries in California and Oklahoma, but for the present, at least, the peak in the Californian production has been passed.

According to "The Mining Journal" (March 8, 1924), the total production, consumption, and imports of crude oil in the United States for the month of January, 1924

*"The Saturday Evening Post," December 22, 1923, p. 49.

(in barrels), were as follows:—Production, 56,354,000; consumption, 62,686,000; imports, 6,303,000.

In a valuable paper by R. E. Thwaites, issued under the direction of the Commonwealth Institute of Science and Industry, it is stated that in 1923 the United States and Mexico produced about 90 per cent. of the world's supply of crude petroleum.*

WORLD SUPPLY OF PETROLEUM.

According to "Mineral Industry," 1922, the world's marketed production of crude petroleum for the year 1922 was 851,540,000 barrels of 42 United States gallons (equivalent to 35 Imperial gallons).

The principal producing countries in 1922 were:—

United States of America	551,197,000	barrels.
Mexico	185,057,000	„
Russia	35,091,000	„
Persia	21,154,000	„
Dutch East Indies	16,000,000	„
Rumania	9,817,000	„
India	7,980,000	„
Peru	5,332,000	„
Galicia	5,110,000	„

Japan, Argentine, Trinidad, British Borneo and Venezuela also each produced upwards of 2,000,000 barrels, and Egypt just over 1,000,000 barrels during 1922.

A record output by the United States of about 745,000,000 barrels is expected for the year 1923.

AUSTRALIAN CONSUMPTION OF LIQUID FUEL.

No definite information can be obtained as to the *consumption* of liquid fuel in Australia, but the importations

*"The Production of Liquid Fuels from Oil Shale and Coal in Australia," Bulletin No. 24, by R. E. Thwaites, M.A.

into Australia during the year ending 30th June, 1922, were as follows:—

	Gallons.	Value. £
Kerosene and other refined petroleum burning oils	15,878,390	779,024
Mineral lubricating oils	4,104,881	489,726
Petroleum spirits, including benzine, benzoline, gasoline, pentane, petrol and naphtha	33,985,098	3,084,938

The figures with regard to the importations into Australia for the year ending 30th June, 1923, are as follows:

	Gallons.	Value. £
Kerosene and other refined petroleum burning oils	21,831,749	789,635
Mineral lubricating oils	6,490,732	614,454
Petroleum spirits, including benzine, benzoline, gasoline, pentane, petrol and naphtha	45,800,212	3,485,228

The importations for the first seven months of 1923-24, *i.e.*, from 1st July, 1923, to 31st January, 1924, are:—

	Gallons.	Value. £
Kerosene, etc.	11,656,504	455,011
Mineral lubricating oils	5,153,281	453,461
Petroleum spirits, including benzine, etc.	31,882,411	2,019,763

ORIGIN OF PETROLEUM.

In considering the possible Australian resources of liquid fuel, it becomes necessary to investigate the question of the origin of petroleum, in order that we may best know where to search for supplies. This question of origin has produced much discussion among petroleum geologists, and various theories have been propounded, each suggestion having to bear the searchlight of investigation.

The genesis of petroleum has been variously attributed to:—

Inorganic Origin: including (1) hypogene causes; and (2) vulcanicity.

Organic Origin: including (1) from animal matter; and (2) from vegetable matter.

The hypogene theory is disappearing from the field of probabilities, and appears to have been little more than a supposition that hydrocarbons may have been formed by the action of water upon metallic carbides which may possibly exist beneath the earth's crust.

The volcanic origin of petroleum has been suggested, but reasonable indications of this source of origin have not been forthcoming, and, as E. H. Cunningham-Craig states, "the theory has not found acceptance among scientific observers."*

This reduces the possible sources of origin to the two organic theories, and each has its coterie of supporters. Cunningham-Craig writes (*supra*) :—"There is a growing tendency at the present time to conduct researches upon the subject of the relations of coals and lignites to petroleum. Every country that contains either coal or petroleum, or both, can furnish some evidence, and it is becoming obvious to geologists that the two fuels have definite relations to each other. It has been pointed out by the writer that the three main oil-bearing horizons in Trinidad have each a carbonaceous phase in some other district, and that the two phases, petroliferous and carbonaceous, approach each other very closely in some localities. Similar evidence has been forthcoming from many countries—e.g., Venezuela, Burma, Assam, Hungary and Rumania" . . . . "Much pertinent evidence from Great Britain was also brought to light by the work of the Petroleum Research Department during the war, but unpublished, and the relations of oil to coal and to oil shale have been made clearer."

*The Mining Journal, Vol. CXLIII., No. 4650, p. 784 (October, 1923).

The work of Dr. Bergius shows that "by treating any coal containing a fair percentage of volatile matter with hydrogen under very high pressure and at temperatures up to 850 degrees F., a remarkable exothermic action is induced, and a portion of the solid fuel becomes liquified, giving as a result a product indistinguishable from heavy crude petroleum."

After quoting the valuable and important researches carried out by Dr. F. Bergius* in the attempt to reproduce some of the conditions, including heat and pressure, approximating to those that must have occurred in Nature during the formation of oil, Cunningham-Craig goes on to say:—"This leads us naturally to a consideration of the different types of vegetable deposit that are known, and their relative stages of alteration and carbonisation. Between peat and anthracite there is every gradation of deposit of vegetable origin, and it has been proved conclusively that the purest, those freest from inorganic contents, attain the coal stage earliest. Those which yield most oils on distillation are the cannels, which are impure deposits containing much inorganic matter in a very finely-divided state."

Mr. Thwaites (*supra*) states that the researches of Dr. Bergius have proved that asphaltic crude oils, tars, pitch and even coal itself, when heated in contact with hydrogen at pressures of about 100 atmospheres, to temperatures of 400°-450° C., not only undergo decomposition or cracking, but the smaller unsaturated molecules combine with hydrogen to form saturated compounds without liberation of carbon or much gas formation.

---

*Dr. F. Bergius in Zeitschrift fur angewandte Chemie, July, 1921.

Cunningham-Craig writes:—"A very rich and fresh torbanite, such as is found in New South Wales, would probably be entirely liquified if subjected to Dr. Bergius' hydrogenation process, but the temperature would require to be kept comparatively low."

"Now that these interesting deposits have been so fully studied, their true significance can be appreciated: they show a stage in the formation of oil from vegetable deposits, checked and arrested owing to the particular environment in each case."

In a publication by the Department of Mines, Sydney, is the following article by Leo. J. Jones:—*

"*Animal Origin.*—The supporters of this theory contend that petroleum and natural gas are formed by the decomposition or destructive distillation of animal matter that becomes enclosed and buried beneath air-tight sediments before the total decomposition of the fatty parts has taken place."

Mr. Jones points out that in certain cases "oil and gas are found in strata containing abundant animal but little or no plant remains, particularly so in the cases of the Canadian, Appalachian, Egyptian, Mexican and Persian oil-fields, where the oil, derived from neighbouring highly fossiliferous shales, is contained in sandstones."

Oils similar to petroleum have been extracted from animal fats in the laboratory.

Plant Origin.—"The similarity of the gases given off by coal in certain mines to the gas in oil-fields, and the fact that coals and lignites, on destructive distillation, yield hydrocarbons of the paraffin and olefine series similar to

*Mineral Resources, No. 31. "Notes on Petroleum and Natural Gas, and the Possibilities of their Occurrence in New South Wales" (1921).

those of petroleum, led to the early belief that petroleum was derived from coal and lignites. Crude oil has been recorded as oozing out of coal beds at Scotland, at Vendee in France, and on the Island of Trinidad."

Some authorities suggest that petroleum has been derived from the remains of gelatinous plants, such as algæ, buried under accumulating sediments and protected from decomposition. Subsequently these remains are distilled into the various oils and gases met with in nature.

In the laboratory it is possible to distil oils resembling crude petroleum from such plants.

Animal and Plant Origin.—The theory assigning the origin of oil and gas to both animal and plant remains appears to be the one most generally held. F. W. Clarke states:—*"Wherever sediments are laid down, enclosing either animal or vegetable matter, there bitumens may be produced. The presence of water, preferably salt, the exclusion of air, and the existence of an impervious protecting stratum of clay seem to be essential conditions towards rendering the transformation possible. Seaweeds, mollusks, crustaceans, fishes and even microscopic organisms of many kinds may contribute material to the change. In some cases plants may predominate; in others animal remains; and the character of the hydrocarbons produced is likely to vary accordingly, just as petroleum varies in different fields. In one region we find chiefly paraffins, in another naphthenes, and in another nitrogenous or sulphuretted oils."

It is considered by different investigators that the variations in the composition of petroleum are not only due to the differences in the organic materials from which it has been formed, but also to the physical conditions pre-

*"Data of Geochemistry," p. 744 (1920).

vailing at the time of formation and to the subsequent migration and resulting filtration that the oil has undergone.

Ziegler gives the following summary of the conditions of oil formation as determined by geological observation:—*

1. That the formation of petroleum is a general process.
2. That the original materials represent both animals and plants.
3. That the process of alteration is one of selective putrefaction and distillation, taking place under the following conditions:—
    (a) At comparatively low temperatures.
    (b) Under comparatively great pressures.
    (c) In the presence of water, usually salty.
    (d) During a great space of time.

Mr. M. E. Wilson † while favouring the organic theories for the origin of oil, discusses those theories in the following terms:—"They are all based on a source of supply for the oil in the organisms which have been imbedded in the rocks. . . . . The earliest theories were based on a source of supply from the remains of plants associated with the coal deposits. The abundance of plant life during certain geologic periods was well known, and natural gas has been found in coal beds at many localities. However, the great deposits of petroleum are not directly associated with deposits of coal, and the type of oil produced from the distillation of coal is chemically very different from petroleum. It is believed by some that asphaltic oils are mainly derived from animal remains, and the paraffin oils from plants. Coal has been produced from terrestrial vegetation which was certainly not sufficiently abundant

---

*Ziegler, "Popular Oil Geology," p. 32 (1918).

†"The Occurrence of Oil and Gas in Missouri," by M. E. Wilson, Missouri Bureau of Geology and Mines, p. 3 (1922).

throughout all of the geologic periods to have produced the wide geologic distribution of petroleum deposits. It seems, therefore, in postulating the source of petroleum from plant remains, that marine plants must be looked to with greater favour than terrestrial plants. Marine plant life also has been abundant, and it is believed that some of our great deposits of oil can be directly traced to these. It is also known that some sea plants give rise to petroleum through decomposition. There is, therefore, good reason to believe that a part at least of the petroleum deposits have been derived from the remains of marine plants."

"There are a very large number of adherents to the theory that petroleum is derived through the slow decomposition of animal matter which has been imbedded in the rocks. Much weight is given to this theory by the fact that animal matter can be converted into oils similar to petroleum in the laboratory, that animal remains are very abundant in the rocks from which the oil is produced, and that the process of conversion of certain of the animal parts into mixtures of hydrocarbons is not difficult of explanation. In fact, there is not much doubt on the part of many students of the subject, but that some of our great oil deposits were derived from the remains of animal organisms in the rocks.

"There are objections to the theory of exclusive origin of oils from animal remains the same as to the theory of exclusive origin of oil from vegetable remains, which have given rise to compromise theories, suggesting that both have played their part in furnishing a source of supply for the petroleum."

From our present store of information on the subject, it would seem that the theory of a separate or combined animal and vegetable origin for mineral oil would probably find most favour, and as the occurrence of oil is very

often associated with saline conditions of deposition, it would appear not unlikely that the vegetable matter which assisted to cause the production was marine algæ.

CONDITIONS FOR OCCURRENCE OF MINERAL OIL.

Commercial supplies of petroleum are only found in sedimentary rocks, except in very rare instances, where they may occur as migratory deposits in reservoirs contained in metamorphic or igneous rocks.

M. E. Wilson* concisely quotes certain fundamental geological requirements which are regarded as of vital importance in connection with the occurrence of commercial deposits of oil or gas. These are:—

(1) A source from which the fuels may be derived.

(2) Reservoir or a stratum of rock which is capable of storing a commercial supply in its pore space or openings.

(3) Cap rock or an overlying bed of rock so impervious as not to permit the upward escape of the oil.

(4) Some structural or textural condition of the rocks which favours a local accumulation.

Opportunities for seepages, and the irrevocable loss of some of the oil, are likely to occur where the rocks have been highly folded or fractured, or deeply dissected, as are the Blue Mountains in New South Wales, much oil thereby escaping over a long period, which might possibly have once been conserved, and, on the law of probabilities, the older the rocks the greater is the likelihood of considerable folding having taken place. The result is that there are a greater number of productive oil-fields in geological areas which are newer than Carboniferous than in

*"The Occurrence of Oil and Gas in Missouri," by M. E. Wilson, Missouri Bureau of Geology and Mines, p. 6 (1922).

those older than that period, and at the present time it is considered that more than half the petroleum of the world, perhaps quite sixty per cent., comes from rocks of the Tertiary period, one of the newest formations.

As soon as oil-bearing rocks have been folded and fractured, they commence to lose their oil, and seepages occur and continue perhaps over an enormous period of time, until the bulk of the oil has gone. Many of the oil-fields of to-day occur in the newer formations where this process of discharging the oil by seepage is in progress, and it is by this very action that attention is drawn to the presence of the oil.

Petroleum is not found in commercial quantities in igneous or intensely metamorphosed rocks. It has been found in formations as new as Quarternary (Pleistocene), and in all those ranging down to as old as Cambrian, and although it may be found in payable quantities in either Silurian, Ordovician, or rarely Cambrian, it is not often known to occur in exceedingly prolific quantities in rocks of any of those ancient periods, exceptions being in the Pennsylvanian areas.

Migration of Oil.—(1) *Gravitation*: M. E. Wilson (*supra*) points out that oil is naturally subject to the force of gravity, and where more effective forces are not involved, it will respond to the pull of gravitation. "The rocks commonly contain more or less water and it is probably very exceptional to find decidedly porous rock which is dry. For these reasons gravitation has not exerted nearly so strong a direct influence on the movement of oil through rocks as have other causes, though it is more indirectly a most important factor. The rare occurrence of oil pools in synclines or basins in the rocks, which would be brought about directly by the force of gravity, are far less common than occurrences beneath anticlines

or upwarped arches where the accumulation has been brought about by forces tending to counteract the natural effect of gravity on oil.''

(2) *Capillary Attraction*: Wilson refers to the well-known effect of capillarity, which causes oil to rise in a lamp wick, or ink to be absorbed in a blotter, and points out that the effect of capillarity in causing the movement of oil is much greater than that of gravity, though it is effective only in the finer grained rocks, and ceases to be a factor of movement in very coarsely porous rocks.

POSSIBILITIES OF THE OCCURRENCE OF PETROLEUM IN AUSTRALIA.

Rocks corresponding to the whole of the geological formations in which petroleum occurs are found in Australia, but those rocks which are older than Devonian are in many cases either highly folded or at least tilted, and often considerably metamorphosed. Our greatest hope, therefore, will not lie in the probability of discovery in these older formations, though the possibility may not be absolutely excluded, especially where these formations are still undisturbed, as in north-western Australia.

Having in view that the consensus of opinion in regard to the origin of petroleum now favours the theory that it is derived from either animal or vegetable matter, or both, it is obvious that we should look among highly fossiliferous sedimentary rocks in order to find the distributing centre or original home of this mineral oil. It would also seem possible that these likely oil-bearing rocks would be of marine origin.

There are large deposits of Silurian fossiliferous limestone of animal origin in Australia, much of which occurs in New South Wales, and it seems possible that these animal remains may have been sufficiently abundant to

have formed a source for mineral oil in some quantity, but during the process of folding, and chemical alteration of the rocks, the great bulk of the oil has probably been lost. The same generalisation applies to sedimentary rocks of the Devonian age, although these strata are less disturbed than those of the older periods, and, in addition to animal remains, contain a fossil plant—*Lepidodendron australe.*

Coming upwards to the Carboniferous formation, we reach the period where the second latest rock folding of any considerable extent occurs in Australia. The rocks of this period contain both animal and plant remains.

The Permian (Permo-Carboniferous) formation, though strongly folded in some places, contains considerable quantities of both animal and plant remains, those of the former being largely marine, while those of the latter are chiefly terrestrial, and have gone to form coal seams, these constituting Australia's most valuable deposits of coal. There seems reason to consider that the conditions necessary for the transformation of vegetable matter into coal, are not the same as those which are required to cause similar vegetation to become mineral oil. At the same time the coal conserves in some degree the ingredients necessary for the production of oil under a system of distillation.

The Triassic formation is of fresh-water origin, and characterised by the paucity of fossils. The thick uniform character of the beds comprising the Hawkesbury and Narrabeen Series of this formation, consisting of sandstones and shales, devoid of limestone or marly bands, deposited for the most part under atmospheric oxidising influences, are most unfavourable for the occurrence of oil, and experience in other parts of the world has shown similar rock types to be barren.

There would thus appear to be little, if any, prospect of ever obtaining commercial supplies of oil from such beds.

The remaining newer systems, which include Jurassic, Cretaceous and Tertiary, in an ascending scale, are composed of beds which, for the most part, are little disturbed in Australia, and contain both animal and plant remains. Provided suitable geological structures occur within these formations, they offer possibilities as a source of supply.

Thus the Tertiary, Cretaceous and Jurassic formations, together with the Permian, and in some cases the Carboniferous rocks, would appear to afford the most likely places where petroleum might be successfully sought.

As against this, however, a shaft about 2900 feet deep has been sunk to the coal at Balmain, Sydney, from near the top of the Triassic beds into the Permian rocks without revealing a trace of mineral oil. Several shafts, some exceeding 1000 feet deep, have been sunk to the coal in Permian formation near Maitland, without any oil being seen, and the same applies to bores which have been put down with a diamond drill. Gas is, of course, met with at a depth, but this is not remarkable seeing that portion of the formation penetrated is of a carbonaceous nature.

It would seem that the question which has to be solved is whether the amount of animal and vegetable remains quite apart from coal and shale, in the rocks of Australia, is sufficient to have supplied mineral oil in anything approaching commercial quantities, and, if so, whether such oil has been retained. Much of the evidence so far obtained during the somewhat limited investigation which has been made is not yet convincing, though the possibility of success still remains, and the question can only be answered by further careful geological survey and boring.

WHAT OF AUSTRALIA'S HERITAGE?

Liquid fuel has become a matter of such vital importance to the progress of all the leading nations of the world that it is imperative Australia should ascertain her possibilities in this connection. Even if petroleum should be found in payable quantities in the Commonwealth, its duration will have its limitations. It is prudent to look for other sources, and in doing so we are reminded of Australia's great heritage in her coal and oil-shale supplies.

Apart from the possibility of finding mineral oil, the sources of supply of liquid fuel in Australia are coal, oil-shale, and vegetation. The most important of these is coal, and yet at the present time comparatively little is being done to produce any liquid fuel from the great bulk of the coal which is being won, the greatest exception being the production of some liquid fuel or motor spirit by the Broken Hill Proprietary Co. Ltd., at Newcastle, and which amounts to about 1,000,000 gallons annually, or about two per cent. of Australia's present annual importations.

RESERVES OF WORKABLE COAL IN AUSTRALIA.

The following estimates of the coal resources of Australia can only be considered as rough approximations. Much more detailed geological work must be done, especially in New South Wales and Queensland, before these resources can be estimated with any approach to accuracy.

For New South Wales the present estimate has been prepared by the officers of the Geological Survey, under the direction of Mr. E. C. Andrews, Government Geologist

For the other States the information has been supplied by the various Government Geologists.

In the Mineral Resources of New South Wales (1901), Mr. E. F. Pittman points out that attempts to calculate

the quantity of coal available in any large area of country are always more or less hazardous, and states that—"Some years ago the late Mr. C. S. Wilkinson, Geological Surveyor-in-Charge, estimated that, within a depth of 4,000 feet from the surface, the New South Wales coal seams, of a thickness exceeding two and a half feet, are capable of producing 78,198,000,000 tons of coal, allowing one-fifth for loss in working."

Subsequently, in 1890, an estimate by Professor (now Sir) T. W. Edgeworth David gave between 130,000,000,000 and 150,000,000,000 tons, not taking into consideration seams of less than three feet in thickness.

After reviewing the position in 1901, Mr. Pittman suggests about 115,000,000,000 tons as the amount available, but makes it clear that the data are insufficient for anything like accurate determinations to be reached. The figures quoted may therefore only be assumed as chiefly indicating possible reserves, the actual reserves being considered to be very much less.

NEW SOUTH WALES.

In the following estimate of actual reserves, no account has been taken of coal below 4000 feet from the surface, and the coal has been classified into three grades:—

Grade A: Coals of first grade quality, suitable for steam raïsing, gas making, and household purposes. Ash from five to twelve per cent.

Grade B: Coals with lower calorific value and higher ash contents than Grade A, but suitable for use in the condition as mined. Ash averaging from twelve to twenty per cent.

Grade C: Coals from inferior seams generally with high ash content, but suitable for use after washing or flotation.

1. Upper Coal Measures.

Approximate tonnage of commercial coal in New Wales.

(a) **Northern** Coalfield—including Curlewis.

A Grade	.. ..	2,150,400,000 tons
B „	.. ..	2,630,400,000 „
C „	.. ..	4,300,400,000 „

Muswellbrook Coalfield.

B Grade	.. ..	480,000,000 tons

(b) Southern Coalfield—including Douglas Park—Berrima.

A Grade	.. ..	2,162,760,000 tons
B „	.. ..	573,120,000 „
C „	.. ..	1,930,420,000 „

(c) Western Coalfield—including Talbragar.

A Grade	.. ..	720,000,000 tons
B „	.. ..	720,000,000 „
C „	.. ..	1,920,000,000 „

(d) Coorabin (Riverina) Coalfield.

A Grade	.. ..	(?)
B „	.. ..	14,400,000 tons

II. Middle Coal Measures.

(e) **East** Maitland Coalfield—including Rix's Creek.

A Grade	.. ..	345,600,000 tons
B „	.. ..	702,700,000 „

III. Lower Coal Measures.

(f) Maitland Coalfields—Lower or Greta Coal Measures.

A Grade	.. ..	1,324,800,000 tons

(g) Muswellbrook Coalfield—Lower or Greta Coal Measures.

A Grade	.. ..	96,000,000 tons

Totals:—

A Grade	.. ..	6,799,560,000 tons
B „	.. ..	5,120,620,000 „
C „	.. ..	8,150,820,000 „

Aggregate	.. .. ..	20,071,000,000

This includes the amount already won, nearly 300,000,000 tons, but as the estimate is only approximate at best, the aggregate quantity might be stated at about 20,000,000,000 tons of actual reserves, while the possible reserves may be accepted for the present, as about 100,000,000,000 tons, in addition.

Practically the whole of the New South Wales coals belong to the bituminous group.

It is difficult to decide what allowance should be made for the loss of coal in winning, for it is impossible to say what improved methods of mining may be evolved in the future, though it is beyond doubt there will be some considerable loss. In the Hetton and Stockton Collieries. under harbour and ocean waters at Newcastle, the bords worked were six yards and the pillars left were eight yards wide, so that nearly sixty per cent. of the coal, which is of excellent quality, has been left. These collieries are now filled with water, but there are mining engineers who forecast the possibility of much of this abandoned coal even yet being won by a system of hydraulic stowing, when the pressing need for coal arrives.

For the purpose of this calculation a twenty per cent. loss will be adopted, so that the actual coal reserves will be considered to be about 16,000,000,000 tons.

The enormous asset which New South Wales has in its coal may be comprehended by estimating the known reserves of about 16,000,000,000 tons at £1 per ton, thus giving a value of £16,000,000,000, and if to this be added the possible reserves, less 20 per cent. which may be lost in working, the value reaches the fabulous figure of about £96,000,000,000 for this State alone.

Average Proximate Analyses of N.S.W. Coals.

The following average proximate analyses have been calculated from a series of analyses made by the Chemists

and Analysts' Branch of the Mines Department, under Mr. J. C. H. Mingaye.

	Greta Seam	Borehole Seam	Burwood Seam	Tomago Seam	Bulli Seam	Lithgow Seam
Hygroscopic Moisture	1.960	2.24	2.43	2.52	0.64	2.29
Volatile Hydrocarbons	40.570	34.98	34.04	33.82	23.18	30.62
Fixed Carbon	50.740	54.77	53.60	51.79	65.21	53.34
Ash	6.730	8.01	9.93	11.87	10.97	13.75
Sulphur	1.168	0.470	0.367	1.082	0.367	0.756
Specific Gravity ..	1.291	1.339	1.338	1.349	1.378	1.441
Calories	7,275	7,381	6,876	6,681	7,274	6,554

VICTORIA.

Information received from Mr. W. Baragwanath, Government Geologist.

Approximate tonnage of extractable *Black Coal*:—

Korumburra, Jumbunna, and Outtrim	2,000,000 tons
Wonthaggi	20,000,000 „
Total (including several small outside areas)	25,000,000 „

Brown Coal.

Estimate as ascertained by boring in various Victorian areas:—

	Tons.
Morwell and District	5,000,000,000
Traralgon and District	5,000,000,000
Walshpool-Gelliondale	250,000,000
Altona	100,000,000
Lal Lal	25,000,000
Wensleydale	3,000,000
Total	10,378,000,000

QUEENSLAND.

Mr. B. Dunstan, F.G.S.* estimates the area of the Coal Measures of Queensland to be 73,000 square miles, of which 20,000 square miles are made up of recognised coal fields,

*Queensland Geological Survey Publication No. 239, "Coal Resources of Queensland," by B. Dunstan, F.G.S. (1913).

namely, 2,000 square miles of Cretaceous age, 2,000 square miles of Trias-Jura age, and 16,000 square miles of Permian age.

The estimated coal reserves include all seams not less than one foot thick and situated at depths not greater than 1,000 feet below the surface.

One square mile around a spot where a coal seam is known is taken as the limit of probability.

The total actual reserves of coal are estimated to be 412,120,000 tons, as under:—

	Tons
Semi-Anthracite	122,500,000
Bituminous	279,250,000
Semi-bituminous	2,600,000
Gas Coal	7,770,000
Total	412,120,000 tons

The total probable reserves are estimated to be 1,684,000,000, as under: —

Semi-Anthracite	629,800,000
Bituminous	828,800,000
Semi-bituminous	157,400,000
Gas Coal	4,000,000
Lignite	64,000,000
Total	1,684,000,000 tons

Probable Reserves.—The principal coal areas lie in the vicinity of Beaudesert, Bowen, Burrum, Callide Creek, Chinchilla, Clermont, Cooktown, Dalby, Dawson River, Hughenden, Ipswich, Walton, Little River, Mackenzie River, Central Railway, Mount Mulligan, Nebo, Nundah, Styx River, Tiaro, Toowoomba, Warwick and Waterpark Creek.

Unprospected coal areas occur in the vicinity of Brisbane, Ipswich, Maryborough, Gladstone, Rockhampton, Mackay, Townsville and Cooktown.

SOUTH AUSTRALIA.

The Coal Mining Industry has not been established in South Australia, but the resources are considerable.

A short note on the several deposits is given by Mr. Keith Ward, in the Annual Report of the Director of Mines, 1922 (pp. 12 and 13), but, although reserves of lignite amounting to over 50,000,000 tons have been proved, it appears probable that this is only a fraction of the total resources.

This report indicates that the best coal in South Australia has been proved at depths of 2,830 and 3,950 feet on a borehole near Robe. The biggest seam intersected in this bore, however, is only three feet in thickness and the horizontal extent is not determined.

Sub-bituminous coal has been recorded at Kuntha Hill and at Lake Phillipson, far from existing lines of transport.

The large deposit at Leigh's Creek is 170 miles from the nearest port.

The composition of these sub-bituminous coals is indicated in the following table:—

Locality and Age.	Sulphur after Air drying.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.
Kuntha Hill, Cretaceous ..	—	11.68	36.63	42.70	8.99
Lake Phillipson, Jurassic	—	21.02	39.48	33.12	6.38
Leighs Creek, Triassic ..	0.24	27.15	25.24	33.68	13.91

These deposits have been only partly explored, and no attempt has been made to indicate the total tonnage of coal.

The Tertiary lignites are known to be widespread, but the tonnage has been determined by boring at the following localities only:—

Locality.	Tonnage.	Area in Acres.	Average Thickness.	Depth.
Noarlunga	1,438,000	80	12ft. 6in.	322 ft.
Moorlands	8,175,000	389	14ft. 8in.	79 ft.
Clinton	32,384,000	620	21ft. 8in.	292 ft.
Lukeman	10,701,000	280	21ft. 7in.	242 ft.
Hope Valley ..	No estimate	200	13ft. 0in.	164 ft.

The horizontal extent of the deposits of sub-bituminous coal and the other known deposits of Tertiary lignite has not been determined. It is not possible to determine the total coal resources of South Australia until detailed surveys of the Coal Measures have been made.

WESTERN AUSTRALIA.

Coal has been extensively mined in only one district in Western Australia, namely, the Collie Coal Field, which has an area of fifty square miles.

The Royal Commissioners of 1914 on the Collie Coal Industry estimated that at a depth not exceeding 2,000 feet the available coal on the field amounts to 3,500,000,000 tons.*

The following is a table of average results of the analyses of the coals of the Collie Coalfield:—

Collieries:—	Co-operative.	Wes-tralian.	Pro-prietary.	Scottish.	Cardiff.
Ash	7.69	8.12	6.40	3.95	4.50
Moisture	19.26	19.30	24.70	24.70	25.10
Sulphur	0.42	0.50	0.40	0.64	0.78
Nitrogen	1.12	1.13	1.15	1.04	0.92
Volatile Hydrocarbons	26.40	26.90	26.20	38.30	32.10
Calorific value, B.T.U. as received	9,803	9,779	9,112	9,354	8,988
Calorific value, B.T.U. ash, moisture free..	13,374	13,486	13,231	13,079	12,670

Other fields which have not been worked extensively are the probable extension of the Collie Coal Field at Wilga,

*Extracted from A. Gibb Maitland's "The Coal Deposits of Western Australia."

the Irwin River Coal Field, the Greenough River, Flybrook, the Vasse, Donnybrook, Millbrook and Kimberley deposits.

A few representative analyses of coal from some of these fields are given below:—

Locality:—	Wilga.	Irwin River.	Flybrook.	Donny-brook.	Kimberley.
Moisture ..	18.43	18.39	13.31	31.34	8.87
Volatile hydrocarbons	29.20	29.87	37.42	28.43	29.73
Fixed carbon.	47.13	40.13	46.45	24.37	33.99
Ash	5.24	11.61	2.82	15.86	27.41
Total	100.00	100.00	100.00	100.00	100.00
Calorific value, B.T.U.	9,253	8,593	10.167	6,315	7,722

Until detailed surveys of these fields are made it is impossible to give estimates of the amount of coal available.

TASMANIA.

The commercial value of the coal in Tasmania varies according to age. The Permian coal includes the humic kerogenites, pelionite and torbanite.

The Trias-Jura coal includes sub-anthracitic and non-caking humic coals, while the Tertiary coals are lignites and brown coal.

The total actual reserve, as given in "The Coal Resources of Tasmania," is 124,980,000 metric tons, consisting mainly of non-caking, humic coal, and 136,000 metric tons of humic kerogenites.

The total probable reserves are estimated to be approximately 123,013,000 metric tons.

This estimate includes 16,200,000 metric tons of sub-anthracitic and non-caking humic coals, and 5,300,000 metric tons of humic kerogenite, the remainder being mainly non-caking humic.

No figures are given for possible reserves.

The sub-anthracites burn with a slightly luminous short flame, and little smoke, and do not coke. They have a fuel ratio of 7 to 12, a calorific value of 15,000 to 15,500 B.T.U., or 8,330 to 8,600 calories.

The total carbon is 90 to 93 per cent., and the volatile hydrocarbons 7 to 20 per cent.

Non-caking humites burn with a short, luminous flame, have a fuel ratio of 1.4 to 7, a calorific value of 12,000 to 14,000 B.T.U., or 6,600 to 7,800 calories. The total carbon varies from 70 to 90 per cent., and the volatile hydrocarbons from 20 to 38 per cent.

The humic kerogenites burn with intumescence with a long, highly luminous flame, giving out a characteristic odour resembling, to some extent, that of burning oil. The fuel ratio varies from .8 to 1.9, the calorific value from 12,000 to 16,000 B.T.U., or 6,600 to 8,800 calories, the total carbon from 60 to 80 per cent., and the volatile hydrocarbons from 40 to 50 per cent.

The principal Coalfields in Tasmania are:—

The Mount Nicholas-Fingal-Dalmayne Coalfield.
The Seymour-Douglas River-Denison R.-Mt. Paul Coalfield.
The Swansea-Schouten Island Coalfield.
The Triabunna-Buckland Coalfield.
The Tasman Peninsular Coalfield.
The Bruny-Strathblane Catamaran Coalfield.
The Sandfly-Cygnet Coalfield.
New Town Coalfield.
The Upper Derwent Coalfield.
The Colebrook Coalfield.
The Colebrook Richmond Coalfields.
The Bagdad-Kempton Coalfield.
Mike Howes Marsh Coalfield.
The York Plains Coalfield.
The Avoca Coalfield.
Longford Coalfield.
The Mersey Coalfield.
George Town Coalfield.
Prevlenna and Barn Bluff-Pelion Coalfield.

NEW GUINEA.

The published information concerning the coal of this area is very limited.

Tertiary lignite* was found on the watershed of the Upper Purari River and in the upper channels of the Curnick River. This coal contains 18-20 per cent. of moisture, and the greatest thickness of any seam examined was 2 ft. 9 in.

Mr. Evan R. Stanley† reports that Brown Coal has been found in the vicinity of Astrolabe Bay, containing 18 per cent. of moisture and low ash. Brown coal of superior value also has been reported in the southern portion of New Ireland.

These occurrences, so far as known, are small.

Boulders of bright, glistening coals, and of good quality, have been noted on the upper reaches of certain New Guinea streams, and it is possible that commercial seams of coal may be found in this area.

CANNEL COAL, TORBANITE, AND OIL SHALE RESOURCES.

These three terms are applied to substances closely related in chemical composition, physical structure, mode of occurrence and origin, in fact they are merely divisions of a class, just as rich, medium, and poor quality coals are similarly embraced.

The generally accepted classification is as under:—

(1) Brown cannel—Applied to Kerosene Shale, Torbanite, Boghead Mineral, and Tasmanite—characterised by a preponderance of spores and pollen. Average ratio of volatiles to fixed carbon up to four to one. Low ash percentage.

* J. E. Carne. On Purari Coal Expedition, Papua. Annual Report, 1911-12. pp. 36, 181.

† Report on Natural Resources, New Guinea. By authority. Parl. Paper No. 18, 1923, p. 64.

(2) Black cannel—Applied to ordinary cannel coals, characterised by a preponderance of carbonaceous or vegetable matter. Average ratio of volatile to fixed carbon 1 to 1. Ash percentage, medium to high.

(3) Shaly cannel—Applied to oil-shales characterised by a preponderance of mineral. Average ratio of volatiles to fixed carbon, 1 to 1. Ash percentage very high.

The term cannel is derived from Canevyl, meaning a candle, from the readiness with which the coal ignites and gives off a steady flame. Only the Brown Cannel or Kerosene Shale variety in New South Wales possesses this property. The other varieties are too low grade and contain too high a percentage of ash (mineral matter), to ignite readily. It may thus be said that so far as the Mines Department has definite information, the only cannel coal of commercial importance in New South Wales is the "Brown" or Kerosene Shale variety.

No information is available by which even a rough estimate of the quantities of Black Cannel (Oil Shales) coals could be made.

Approximate tonnage of Torbanite (Brown Cannel).

1. New South Wales. Oil Shale or "Kerosene Shale," as it is known generally in New South Wales, occurs for the most part in the form of isolated lenticular areas rarely more than a mile in length or width on certain horizons of the Upper and Lower Coal Measures.

The principal deposits yet discovered are those in the neighbourhood of Newnes (Capertee Valley), Hartley Vale, Katoomba, Murrurundi, Joadja, Baerami and Barigan. Small patches have been discovered also in the Lower or Greta Coal Measures, at Greta and Clyde River, and recently a bore in these Measures at Muswellbrook passed through a four-feet seam of kerosene shale.

The following list indicates the geographical position of the principal deposits:—

Murrurundi	115 miles by rail north-west of Newcastle.
Baerami	18 miles to railway, 120 miles west-north-west from Newcastle.
Newnes (Capertee-Wolgan Valley) ..	31 miles by private railway to Newnes Junction, which is 88 miles westerly from Sydney.
Hartley Vale	82 miles westerly from Sydney.
Katoomba	63 miles westerly from Sydney.
Joadja	18 miles by road from Mittagong, which is 82 miles southerly from Sydney.
Barigan	About 15 miles north-east from Lue, on the Mudgee Railway Line, 173 miles from Sydney.

In addition to the above localities, numbers of small areas of oil-shale are known to occur in the Capertee Valley, as at Airly and Crown Ridge.

The composition of the oil-shale varies considerably, as is shown by the following table of average proximate analyses:—

Locality	Moisture per cent.	Volatile Matter per cent.	Fixed Carbon per cent.	Ash per cent.
1. Joadja	0.52	68.10	15.03	16.35
2. Katoomba	0.66	65.86	18.60	14.88
3. Hartley Vale	0.36	71.50	6.71	21.53
4. Murrurundi	1.73	57.65	9.47	31.34
5. Capertee-Wolgan	0.45	61.36	14.13	24.04
6. Baerami	0.43	58.14	9.36	32.06

1. Calculated from analyses of fifteen samples.
2. ,, ,, twenty-five samples.
3. ,, ,, two samples only.
4. ,, ,, five samples.
5. ,, ,, eighteen samples.
6. ,, ,, five samples.

(No. 3 samples are from the Old Hartley Vale Mine).

The yield of crude oil per ton of kerosene shale ranges from 75 to 120 gallons for the better classes of shale. Ex-

ceedingly rich areas mined at Hartley Vale returned from 150 to 160 gallons, while as much as 170 gallons per ton has been obtained from oil-shale retorted at Joadja, although the average yield was considerably less than this figure. In recent retorting practice by the Commonwealth Oil Corporation at Newnes, the average yield was approximately 80 gallons of crude oil per ton of shale retorted.

The deposits in the Capertee and Wolgan Valleys, near Newnes, are the most extensive within the State, being proved over large areas. In thickness the seam varies from 14 to 50 inches, and, on the Capertee side, one tunnel has exposed an average thickness of between three and four feet, over a distance exceeding 4,000 feet.

The best shale has been removed from Hartley Vale, Katoomba and Joadja, but quantities of less valuable shale may be available in these areas. A considerable amount of prospecting is required still to prove the extent of the deposits at Barigan, Baerami and Murrurundi.

Several types of retorts have been worked successfully in New South Wales. In recent years retorting and refining have been done at Newnes. Here a bench of 64 retorts was erected, having a daily capacity of 100 to 120 tons of shale. From this quantity of shale, the yield of crude oil would be about 9,000 gallons, the finished products from which would be represented as under:—

	Per Cent.	Gallons
Fuel Oil	20	1800
Gas Oil	25	2250
Kerosene	20	1800
Benzine and Spirits	5	450
Wax	5	450
Loss in treatment	25	2250
		9000

By-products:—

(1) Sulphate of ammonia. About 22 lbs. of this product are obtained from one ton of shale.

(2) Oil-coke, which is obtained from the coking stills, and is used for household purposes.

It is estimated that the probable reserves of kerosene shale within the Capertee-Wolgan-Glen Alice area are approximately 20,000,000 tons. The average content of crude oil per ton of shale would appear to be about 100 gallons, giving a total quantity of 2,000,000,000 gallons, or 50,000,000 barrels available in this area, though at present only about 80 gallons per ton are recoverable.

Of the remaining deposits, those at Bathgate, Baerami, Barigan, Airly and Murrurundi appear to be the most important. At the present time, there is not sufficient information available for the estimation of the reserves in each area, but there is a high expectation that the total quantity of shale available in these deposits may approximate the estimated "Reserves" of Capertee-Wolgan. The average grade of the kerosene shale from the remaining deposits, however, would appear to be generally somewhat less than that of the shale mined in the Capertee-Wolgan areas, and the average content of crude oil per ton of kerosene shale may be approximately 75 gallons; so that the total quantity of kerosene shale expected to be won from deposits within the State may be approximately 40,000,000 tons, containing 3,500,000,000 gallons of crude oil.

SUMMARY.

THE COAL AND OIL RESOURCES OF AUSTRALIA.

1. Coal Resources.

Estimated reserves, additional reserves and possible reserves of coal in various States and Territories.

State or Territory.	Reserve Tons.	Prob. Additional Res. Tons.	Possible Add. Res. Tons.
N. S. Wales	20,000,000,000 (including small amount of probable reserves).		Very large, probably as much as 100,000,000,000—on the assumption that the undeveloped area produces only 40% by volume per acre of the known colliery areas.
Queensland	410,000,000	1,684,000,000 (approx.)	Large— 13,000,000,000 (Dunstan Min. Index, 1913).
Victoria	10,500,000,000 Brown Coal. Approx. Includes prob. Reserves, and 25,000,000 tons black coal.		Apparently not large outside reserves.
Sth. Australia	50,000,000	No estimate.	Moderately large.
W. Australia	3,500,000,000 (being combined Reserves and prob. Reserves).		Apparently not large outside reserves.
Tasmania	125,000,000	123,000,000	Apparently not large outside reserves.
New Guinea	No estimate.	No estimate.	No estimate.
N. Territory	No estimate.	No estimate.	No estimate.
Total	34,585,000,000		

2. Oil Resources.

(a) From "Oil Shale."

In this estimate, a rough indication only is supplied of the amount of crude oil recoverable from the various types of oil shale. All this oil is considered here as "crude oil" or fuel oil.

"Oil shales" occur in vast quantities in the Northern Hemisphere, but are much neglected to-day, with the exception of Scotland deposits, owing to the relative cheapness of crude or petroleum oil. Only a portion of the crude or fuel oil from bores or oil-shales, may be considered as motor spirit.

State or Territory.	Reserves and Probable Reserves. Tons.	Gallons.	Remarks.
New South Wales	40,000,000	3,500,000,000	Mainly Torbanite
Tasmania	42,800,000	1,771,000,000	" "
Queensland	Not known	Not known	Apparently small
West Australia	"	"	" "
South Australia	"	"	" "
Northern Territory	"	"	" "
Papua	"	"	V ry little geological work completed in Papua.

(b) From Coal.

The treatment of certain coals in New South Wales for coke-making purposes indicates that the by-products obtained during such process may be estimated to include, among other things, two gallons of light oil suitable for motor spirit, besides tar, per ton of coal. This tar constitutes an excellent fuel with a calorific value much exceeding that of the coal in equal weights, but, in ordinary circumstances, its use for fuel could not be considered a commercial procedure, because the greater portion of the tar would be too valuable for other purposes. In a national emergency, however, it might be needed as a fuel, hence its inclusion in this report as a possible source of fuel.

State or Territory.	Reserves. Gallons.	Prob. Reserves. Gallons.	Poss. Resources. Gallons.
N. S. Wales	40,000,000,000 (includes some Prob. Reserves).	Included under Reserves.	Very large, probably as much as 200,000,000,000 outside reserves.
Queensland	820,000,000	3,368,000,000 (approx.)	26,000,000,000
Victoria	21,000,000,000 (approx.)	(Combined Reserves & Prob. Res.)	Apparently small outside reserves.
Tasmania	250,000,000	246,000,000	Apparently not large outside reserves.
Sth. Australia	100,000,000	No estimate.	Apparently fairly large.
W. Australia	7,000,000,000	(Combined Reserves & Prob. Res.)	Apparently not large outside reserves.
New Guinea	No estimate.	No estimate.	No estimate.
N. Territory	No estimate.	No estimate.	No estimate.
Approx. Total	69,000,000,000		

This estimate is very conservative, as it is based on the assumption that the whole of the coal would be reduced to coke in the first place. It is, however, much more likely that a low temperature carbonisation would be adopted, whereby the quantities of light and heavy fuel oil would be very greatly increased as compared with those yielded as by-products from coke-making.

TREATMENT OF OIL-SHALES.

It has been demonstrated that retorts suitable for the treatment of low grade oil-shales are not satisfactory for dealing with high grade material, such as that which may yield upwards of 70 gallons of crude oil per ton. It would seem that much of the possible future success in regard to the treatment of some of our best oil-shales depends upon

the devising of satisfactory and improved methods of retorting. This problem, which remains to be solved, is one of great economic importance, for if the cost of production can be reasonably reduced, then the great asset which exists in the oil-shales of New South Wales, which contains some of the richest oil-shales in the world, and in Tasmania, can be availed of. Costs of mining and transport are also factors which contribute to the difficulty of obtaining profitable results.

Two retorts of different types have recently been introduced to deal with the high grade oil-shales of Australia, but there has not yet been time definitely to prove their undoubted success. In each case the retort can be run continuously, and the waste or hard gases given off the shale are utilised to maintain the heat of the retort. One of these retorts is of the internal combustion type, in which the flame is in contact with the shale, and is on somewhat similar lines to some which have already been used. Full particulars regarding the economic advantages claimed for the retort are not available.

In the other retort, the method of applying the heat to the shale is entirely different. In this case the heat is generated in an auxiliary column fitted with tubes. This column is connected with the retort at both top and bottom, and the hot air in the column is forced down by a blower at the top, and enters the retort at the bottom and passes up through the mass of shale in the retort. By the use of certain mechanical appliances the residue discharged is automatically equalled by a charge of "green" oil-shale on the top. In a number of experiments carried out in a model retort of one half ton capacity it has been demonstrated that the shale is completely retorted in from five to six hours, or in about one-fifth of the

ordinary time. Under this method, carbonisation on the walls is practically negligible. It is claimed that the nitrogenous matter in the shale is retained in the residues, and in some cases the ammonium sulphate present is equal to 42 lbs. per ton of shale treated. The residue is said to have sufficient gas in it for heating the retort. If this is found to operate in bulk treatment, it will show a definite improvement over the Scotch system, where the residues are inert.

BY-PRODUCTS FROM COAL.

A considerable quantity of coal is used in Australia for the production of gas and coke, and in the process of obtaining these two commodities, or either of them, it is possible also to secure the following by-products:—Sulphate of ammonia, distilled tar and pitch, fuel oil, creosote oil, solvent naphtha, motor benzol, and pyridine.

In the Illawarra district of New South Wales, for the five years ended 31st December, 1923, 1,312,702 tons of coke were produced, and in the process, not one of the above by-products was recovered, the whole being irrevocably lost.

	Illawarra coke produced. Tons.	Coal used for the manufacture of coke; coke estimated at 69% of coal used. Tons.
1919	236,546	342,820
1920	280,568	406,620
1921	289,670	419,812
1922	191,626	277,719
1923	314,292	455,496
Total five years	1,312,702	1,902,467
Ttl., ten yrs., 1914-1923	2,833,799	4,106,955

At some of the Illawarra coke works a portion of the gas produced is turned to good account, and used for

steam raising and for generating electricity, which is made use of for purposes connected with the carrying on of colliery work, as well as for street lighting and domestic purposes, though it is thought greater use might be made of the waste gas for generating electricity.

For several years conferences have been held between the Department of Mines and the coke producers, with the object of devising means whereby this great national waste of by-products might be avoided, but the difficulty lies in the economic factor, including suitable markets, and it cannot be shown that under present conditions these by-products can be recovered at a profit. The trouble largely arises from the fact that the class of oven used in Illawarra for coke making, and known as the beehive type, is not suitable for saving the by-products, although they meet the requirements for making coke, and to scrap these structures and build by-product ovens would be a sacrifice, and would also involve very considerable expenditure. Any scheme to erect a plant solely for the purpose of recovering by-products, and not to include coke making, is, under present local conditions, considered to be unsound financially. At the same time, a valuable national asset is being gradually but surely depleted, without the State receiving full value for the commodity being used.

The words of Sir John Cadman, Technical Adviser of the Coal Mines Department, Great Britain, in his Presidential address to the Institute of Mining Engineers at Stoke-on-Trent, are worthy of being repeated here. His statement was:—"While the popular view of coal is that it is something to be burned, the scientific view was tending to be precisely the opposite. It is that coal is too valuable to be burned, that to burn it is to squander it, that the by-products of coal are of greater moment than

the coal itself, and that not until these by-products have been extracted should the residuum be used for industrial or domestic purposes."*

The reduction of all coal to coke, however, is not yet likely to be adopted universally for the sake of the derivable by-products.

Borehole Coal.—At Newcastle, the Broken Hill Proprietary Company, Ltd., at its steel works, is manufacturing coke, and has 224 by-product ovens. Through the courtesy of this Company, I am able to say that the coal used, which is from the Borehole seam, in the Upper Coal Measures, produces per ton of coal:—

(a) Coke—12 cwts.
(b) Nut Breeze, 40lbs.—Used as blast furnace fuel.
(c) Fine Breeze, 160lbs.—Burnt under boilers.
(d) Gas—11,500 cu. feet. After being stripped of its by-products, 60% of this is required for heating the ovens, leaving 40% available for industrial heating.
(e) Tar—7 gallons.
(f) Ammonium Sulphate—23lbs. Australian market limited.
(g) Benzol (motor spirit)—2 gallons.
(h) Solvent Naphtha—0.14 gallons.

Average analysis of B.H.P. Crude Tar:—

Water		4.0%	
Light oil	0°—170°C.	2.35%	
Middle oil	170°—230°C.	10.11%	Carbolic and Cresylic acid.
Heavy oil	230°—270°C.	11.15%	=25 % of this fraction or 5.31% of tar.
Anthracene oil	270°—400°C.	18.8 %	
Hard Pitch ..		53.59%	

Greta Seam.—From investigations made, it is known that a ton of coal from the Greta seam will yield approximately as follows:—

*Transactions of the Institution of Mining Engineers. Vol. LXII. Part 4, p. 290 (1922).

Coke	10 cwts.
Sulphate of Ammonia ..	26.7 lbs.
Distilled Tar and Pitch	11.4 gals.
Heavy Fuel Oil	2.5 gals.
Creosote Oil	2 gals.
Solvent Naphtha	.5 lbs.
Motor Benzol	.9 lbs.
Gas	between 11,000 and 13,000 cubic feet, obtained by destructive distillation.

Illawarra and Western Coal.—From comparative analyses made in the Mines Department, a ton of Illawarra coal (Bulli Seam), or of Western coal (Lithgow Seam), is estimated, by Mr. H. P. White, to yield somewhat under two gallons of light fuel oil, while a ton of Greta coal, coked under similar conditions, would yield almost 2½ gallons.

Morwell Coal, Victoria.—The Government Geologist of Victoria gives the yield of fuel oil from the Morwell brown coal as 2.92 gallons.

From these results it is proposed to adopt an estimate of two gallons of light fuel oil as the average yield from a ton of Australian coal under present methods of production from coking.

If the methods which are being investigated by Dr. Bergius prove commercially successful for the manufacture of a liquid similar to petroleum by the application of hydrogen to coal, then the production of liquid fuel from a ton of coal will be increased very many times.

HEAVY FUEL OIL.

Motor spirit or motor fuel, which is vaporised for the purpose of producing power by combustion, has been referred to in this address as distinct from heavy fuel oil, which has to be burnt as other fuels for the purpose of heating and producing power from steam, and which

is used in steamboats. Heavy fuel oils are contained in the tar distilled from coal, and in the case of the Borehole Seam at Newcastle the yield of tar is about seven gallons from a ton of coal, after it has been stripped of its motor spirit, but this amount is exceeded in some of the other coals. Quite half of this tar could be converted into heavy fuel oils, though at present it is considered to be more valuable for other purposes. With so much mineral oil available, there is no pressing necessity for using the heavy oil from coal as a liquid fuel.

If a tentative figure of, say, four gallons of heavy fuel oil be adopted as the product of a ton of coal, then under present methods of extraction as a by-product, the total amount of heavy fuel oil which may be produced in Australia from coal would be twice that quoted for motor spirit or light fuel oil.

LIQUID FUEL FROM VEGETATION.

It is highly desirable that every effort should be made to investigate thoroughly all possibilities of obtaining liquid fuel from vegetation, as the supply from this source may be replenished by fresh growths of the producing plant, whereas once the petroleum is obtained from the earth, or the oil is extracted from coal and shale, there can be no further supplies from these sources.

The principal vegetable products are discussed in Bulletin No. 6 of the Advisory Council of Science and Industry (1918).

Practically all vegetable material would become a potential source of power alcohol if the price of petrol were considerably increased.

Alcohol can be produced from all substances which contain fermentable sugar or some component which can be converted into a fermentable sugar, and a convenient

list of such substances is that given in Bulletin No. 6 (*supra*).

(a) Sacchariferous substances, such as grapes, sugar cane, sorghum, and beets.

(b) Amylaceous (starchy) materials, such as maize, wheat, barley, and potatoes.

(c) Cellulose, such as saw-dust and wood lyes from paper-pulp mills.

(d) Inorganic substances, such as acetylene, from which alcohol may be made synthetically by combination with other materials.

That so many proposals to manufacture power alcohol have failed to materialise is strong evidence that at present there is no vegetable material, apart from sugar cane molasses, from which alcohol can be produced remuneratively.

Wheat and maize will yield upwards of 80 gallons of alcohol, and barley about 70 gallons per ton, but these substances are too valuable as food-stuffs to be used for the purpose of producing alcohol. Molasses will yield upwards of 60 gallons of alcohol per ton.

Molasses.—It is estimated that in 1924 about 84,000 tons of molasses will be produced in Australia, 78,000 tons of this coming from Queensland, and 6000 tons from northern New South Wales. This could, if all used for distillation, produce about 5,000,000 gallons of alcohol. These figures have been made available through the courtesy of the Colonial Sugar Refining Company Ltd.

Of the Queensland output of molasses, 40,000 tons will come from the north of Townsville, within the tropics, and owing to the sustained high temperature of the cooling water in distillation in the tropics, the value of the resultant alcohol is reduced if produced in that hot climate.

The molasses has a fuel value at the mill, so cannot be regarded as valueless even there. Before it can be turned into spirit, the molasses must be carried to the water front and shipped to the distillery, or local distilleries must be built to deal with it on the spot, and this involves corresponding charges for transport of the finished article, for fuel supplies, etc. A land freight with attendant charges of twenty shillings per ton of molasses is quite possible, which adds four pence per gallon to the cost of the spirit. A sea freight with attendant charges of thirty shillings per ton of molasses is also quite possible, which means an addition of six pence per gallon to the cost of the spirit.

A large amount of molasses is required locally for stock feed, and many of the mills are so situated that the cost of transport to any position where it could be available for alcohol is prohibitive. In this way the amount of molasses available for alcohol is materially reduced. If half of the total molasses were distilled, it would yield 2,500,000 gallons of spirit. About 1,500,000 gallons are required for industrial purposes of various kinds, hence there only remain a potential 1,000,000 gallons of molasses alcohol available for motor spirit under present conditions.

Burrawang.—This is a native plant (*Macrozamia spiralis*), which occurs in many coastal districts of New South Wales. It has a trunk of 2 or 3 feet, with a diameter of from 1 to 2 feet, and produces long palmate leaves. The trunk and the bases of the leaves have been used for the production of starch, but the results have not been very satisfactory. These Zamia palms are very plentiful on the lower portion of the Clyde River, and a treatment plant was erected a few years ago, near Currowan, above Nelligen, for the purpose of extracting the starch. Burrawangs are somewhat awkward things to

collect, which adds to the cost of the work, and the gathering and treatment are rendered more difficult from the fact that the sandy soil in which they usually grow gets deposited between the bases of the leaves and the trunk, and quickly blunts the implements used for cutting up the stems, besides rendering the extraction of the starch more difficult.

In the Bulletin No. 6 of the Advisory Council of Science and Industry the amount of alcohol (95 per cent.) which these plants may yield is quoted at 18 gallons per ton.

From information kindly supplied to me by Mr. Edward Elliott, of Reckitts (oversea), Ltd., concerning the experiments at Nelligen, it may be stated that one ton of trunks of over thirty lbs. weight, including the outer and inner core, would yield about 3 cwt. of crude starch, which, in its turn, would give up to twenty gallons of alcohol. It is possible that the direct treatment of the plant for alcohol would give much lower results. The granule of the starch is larger than that obtained from maize and rice, which is a disadvantage for the present day uses. The trunks, when landed at the works, contain at least 50% of moisture.

The following figures are the results of numerous experiments:—

	Leaves.	Core.
Proteins (soluble in water)	.25	.60
Proteins Colloidal (insol. in water)	2.90	2.35
Sugars, etc., soluble	4.85	3.95
Fibre	29.20	21.35
Starch	13.10	20.65
Water	49.70	51.10

It seems evident that any prospect of commercial success in the treatment of the Burrawang will lie in the recovery of the starch and alcohol, conjointly with the utilisation of the fibre.

Other Plants.—So far, the treatment for power alcohol of Prickly Pear, Grass Tree (*Xanthorrœa*), and sawdust from Australian timbers, has not been found to be a commercial success, though the latter have a potential value if other products, including fibre and pulp, be exploited as well.

DURATION OF COAL SUPPLY.

From these and similar investigations, it is clear that Australia's potential wealth in regard to liquid fuel supplies lies in her coal resources.

At the present time, the annual production of coal in New South Wales is just upwards of 10 million tons, and could easily be made much greater. By the year 1945 the output should be in the vicinity of 20 million tons, at which rate the State's actual coal reserves, less 20 per cent., of approximately 16,000 million tons, would last for 800 years. If the whole of the motor spirit were extracted from this coal, at the rate of two gallons per ton, it would yield about 40 million gallons annually, which is something less than Australia's importations at the present time.

If we estimate an annual coal output of 40 million tons in New South Wales, the actual reserves, less 20 per cent., would last 400 years, and a full extraction of motor spirit as a by-product would then give 80 million gallons a year, an amount which very soon will be required annually to satisfy Australia's demands.

The total actual coal reserves in Australia, less 20 per cent., are estimated at approximately 27,660 million tons, which, at a two gallons per ton yield, would give 55,320 million gallons of motor fuel. With a prospective coal output for Australia of, say, 50 million tons annually, the supply would last about 550 years, and, with a full ex-

traction of motor fuel as a by-product, the annual yield would be 100 million gallons, still not enough for Australia's future requirements.

The position would, of course, be helped in all the foregoing cases, by the yield of some portion of the 5000 million gallons of shale oil of New South Wales and Tasmania.

AUSTRALIA HOLDS THE ASSETS.

In arriving at the total possible annual production of motor fuel from coal, no calculation has been included to show what the result would be if the whole of the possible coal reserves of Australia were exploited. So far as New South Wales is concerned, if the additional possible reserves of something like 100,000 million tons, less 20% which may be lost in winning, or, say, 80,000 million tons be included, then the previously stated quantities both of coal and oil may be increased by the addition of five times the original amounts quoted, so that 16,000 million becomes 96,000 million tons of coal, and the 32,000 million gallons of motor oil becomes 192,000 million gallons.

The data upon which these larger estimates of quantities have been made are so scanty and imperfect, and actual future production and requirements so uncertain, that at best it is only possible to form some imperfect judgment in regard to the future position. Five points, however, which have a definite bearing on the whole question stand out conspicuously. These are:—

(1) That under present methods of treatment the amount of coal being mined annually is insufficient to provide all the motor fuel required in Australia for the same period.

(2) That of the coal being mined only a small portion is being used for the extraction of oil, and this is only recovered as a by-product.

(3) That there seems little prospect in the near future of the annual production of coal, even with a full extraction of motor fuel under present methods, being sufficient to supply the necessary oil requirements of Australia.

(4) That it is imperative the most intense research should be undertaken to devise, on commercial lines, some method of treatment of coal by which a very much higher percentage of liquid fuel may be extracted or manufactured from this commodity than is obtained by present-day methods, or that some other process such as that of combustion of finely divided particles, may be perfected by which the power may be obtained direct from coal without converting it into oil.

(5) That in its actual, probable, and possible coal reserves Australia holds an enormously valuable asset.

The problem which remains for solution is one for Commonwealth consideration, and calls for scientific and technical research, the latter to include the commercial aspect of the position, both present and future, and particularly on the lines of cheapening and increasing production. Some economic method should, if at all possible, be devised to secure the recovery of the by-products before the coal is finally consumed, but it is abundantly clear that no scheme will be accepted unless it is sound financially, and this condition can be reached quickest, and the wastage arrested, by intense research.

DIFFERENTIAL ELEVATION NEAR SYDNEY.

By Charles Hedley, F.L.S.

(With Plates I., II. and text figure.)

(*Read before the Royal Society of N.S. Wales, June* 4, 1924.)

We owe to Mr. E. C. Andrews the observation that recent elevation is shown by raised terraces at the base of sea cliffs in the vicinity of Sydney.

The best preserved and most lofty terrace of marine erosion, that I have seen near Sydney, is one in Bluefish Bay on the east coast of the Quarantine Reserve on the North Head of Port Jackson. There is no reference to this in literature. Here cliffs rise for about two hundred feet in a continuous and precipitous wall, composed of massive sandstone in which a thick seam of soft shale is intercalated. From this point the strata are dipping steadily and rather rapidly westwards. These cliffs are protected from the attack of a constant surf from the open ocean by a fender of raised terraces at their feet. Upon the upper ledge is piled a disorderly stack of angular blocks, from five to fifteen feet high, which have tumbled from above; these conceal the angle in which cliff meets ledge. A luxuriant growth of maritime shrubs and herbs surrounds the talus blocks and ascends the ledges of the cliffs, showing at a glance that this zone is now at peace and temporarily out of action in the battle with the sea.

The uppermost terrace, of which the largest fragment survives at the head of the bay, has been preserved from the destructive surf of the stormy south-east quarter, by

the shelter of a headland to the south. Beyond this residual the waves have cut back through all the terraces and recommenced attack on the high ground.

Three benches of marine erosion are plainly visible; first, that which is now in process of excavation at about half-tide level; second, a broad intermediate terrace which is everywhere conspicuous and which is washed only by storm waves; third, the highest terrace, swept only by spray, this has survived only in favourable positions.

Some inequalities suggest that pauses in elevation left their marks in other intermediate terraces. But the levels of these terraces never present exact alignment; erosion is proceeding irregularly, the waves quarrying out the rock along lines of weakness in the stratification, so where such lines ascend or descend from the horizon of base levelling, there both the older and newer terraces jump accordingly.

The uppermost terrace is from twenty-five to thirty feet above that now being formed by the waves and is only watered by spray in a gale; it was generally reduced by the surf after the first uplift to the narrow ledge on which stand the fallen blocks. But a residual at the head of Bluefish Bay, the scene of Plate I., figs. 1, 2 and Plate II., fig. 1, is unusually wide, projecting twenty-five yards from the base of the cliff; the floor of this terrace is much weathered, being worn into deep furrows, where a little grass and a few herbs grow.

The intermediate terrace is about six feet above the bench now under construction; being younger than the one above, it is better preserved and reaches at the quarantine boundary a breadth of forty yards. This breadth conveys a time measure of the interval between

the first and second uplifts. Gales have sufficient control over this terrace to sweep it clear of fallen blocks. From the freshness of this terrace and the rapid rate at which the new bench is being driven through it, the date of its elevation must be fairly modern, perhaps two centuries ago.

Situated three miles in a direct line south-west of Bluefish Bay is Wyargine Point, west of Edward's Beach, at the entrance to Middle Harbour (Plate II., fig. 2). Here the succession of beach terraces is repeated, but on a lesser scale. From here, a broad view of the open ocean is seen between the Heads, so that an easterly gale is able to direct a rather heavy surf upon this shore. The cliff wall is lower than that of North Head, but resembles it in being clothed with trees and shrubs and in being fenced in with huge fallen blocks standing on an upper terrace. The highest terrace, surviving only in a few narrow fragments, about five yards in breadth, is eight feet above the intermediate terrace. The latter is about thirty-five yards broad and stands two or three feet above that now in process of erosion.

Comparing Bluefish Bay and Wyargine Point, a rise in the east of thirty feet is found to decrease to ten feet in a space of three miles. The abrupt termination of each terrace indicates a sudden rather than a gradual movement. In each case the upper terrace is narrow and the intermediate is broad, showing that after the first elevation there was a lapse of time without movement during which the sea cut back a corresponding wide shelf. Excavation proceeded more rapidly because there was no overload of cliff to remove as at first. In both cases the first jolt upwards was much greater than the second. Proceeding westward along the reaches of Sydney Harbour for another mile or so, these terraces

disappear, and the only shelf visible is a small one now being cut by the weak waves of sheltered water.*

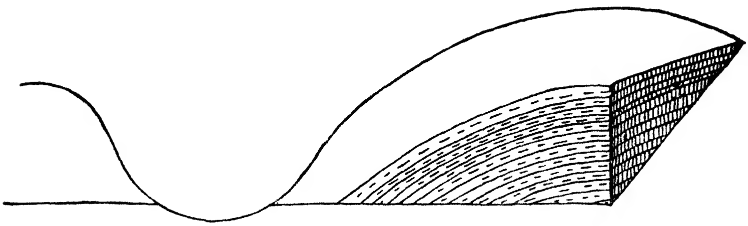
From the foregoing facts it may be deduced that the North Head has risen repeatedly on the crest of a recent fold or long earth wave, with a height of at least thirty feet and a length of more than six miles, and this was followed by a corresponding trough. For the elevation now described is correlated with a recent depression of at least five feet which happened during the existence of aboriginal man, at Shea's Creek, near Botany Bay, and was described by Etheridge, David and Grimshaw.† This incident was ascribed by those writers as due to a rise in the level of the sea rather than to a sinking of the land. A broader view of this depression, whose axis of subsidence strikes the coast between Cronulla and the Boat Harbour, is given by Prof. T. G. Taylor in his article on the "The Warped Littoral around Sydney." (This Journal, 1923.)

Unequal and simultaneous elevation of these shore terraces proves decisively that it was the land which rose and not the sea which sank. The theory of Daly's glacial control is not involved here. But the movement which shaped the mass of North Head was of a different order of events, being far older, more violent and involving less depth of strata. Like many hills which face the ocean along this coast, North Head is somewhat dome-shaped, strata dipping from the centre towards west, south and north, and being truncated on the east. On

*A similar "old elevated shore-line" on Murray Island, Torres Straits, is illustrated by A. G. Mayer.—Papers, Dept. Mar. Biol., Carnegie Inst., ix., 1918, p. 9, Pl. 4, fig. B. Another was observed at Holbourne Island by the Pan-Pacific excursion to the Great Barrier Reef, and will be described by Drs. Richards, Marshall and Walkom.

† Journ. Roy. Soc. N.S. Wales, xxx., 1897, p. 179.

the inland side these elongate domes are habitually followed first by a crescentic trough and then by another ridge, so that a little subsidence would make these hills into a row of off-shore islands.



The structure of North Head has a morphological resemblance to the Flinders Group in North Queensland, lately studied by Professor H. C. Richards and myself, our description of which is about to be published.

Capes like the North Head of Sydney, where a low neck links high land to the main, though unusual in Europe, are characteristic and frequent in Eastern Australia. It is proposed to name this pattern the "Upstart" type, after the first example figured and described by Commander J. Lort Stokes (Discoveries in Australia, i., 1846, p. 333).

I suggest that these coast hills were caused by strata being thrust across an uneven bed, when the buckled strata reared into these dome elevations. When a stream runs over a rapid, boulders in the river bed produce similar figures on the surface of the water. The sheet of flowing water, on meeting the obstruction under foot, first rises into a dome, then descends into a crescentic furrow and lastly swells into a short steep crescentic wave that often breaks.

The undulatory movement here described seems to have been the last earth movement in the Sydney district.

Before that, there was evidently a considerable subsidence, and before that again a severe deformation.

EXPLANATION OF PLATES.

Plate I.

Fig. I. Triple rock shelves at Bluefish Bay. The highest is thirty feet above the water, and is seen in profile against the sky. A figure stands on the intermediate shelf, which is continued across the chasm to the foreground. The lowest shelf, now in process of formation, is clothed with sea weed and washed by the surf.

Fig. 2. View north-westwards taken from the highest shelf of the previous photograph. The immediate foreground, where the figure is seated, is roughened by aerial erosion. In the middle distance is another remnant of the same horizon. Between them extends the intermediate shelf. Three fishermen stand on the lowest shelf. Note the old cliff, removed from action of marine erosion, masked with brushwood and bordered by a belt of fallen blocks. At an earlier period the cliffs rose from the line where the surf is now breaking.

Plate II.

Fig. 1. Bluefish Bay looking south, showing in the centre the highest residual of figures 1 and 2. In the distance is the headland which shelters and preserves the terrace fragment from the stormy quarter.

Fig. 2. Wyargine Point on Middle Harbour, below Mosman. The level summit of the highest residual lies between the standing figure in the centre and the flight of steps to the left. In the immediate foreground on the left, and again to the right, is the floor of the intermediate shelf, across which fallen and storm driven blocks are strewn. The cliff behind is overgrown with *Gleichenia, Pittosporum, Westringia* and other maritime plants.

I owe these photographs to the kindness and skill of my friend, Mr. Anthony Musgrave.

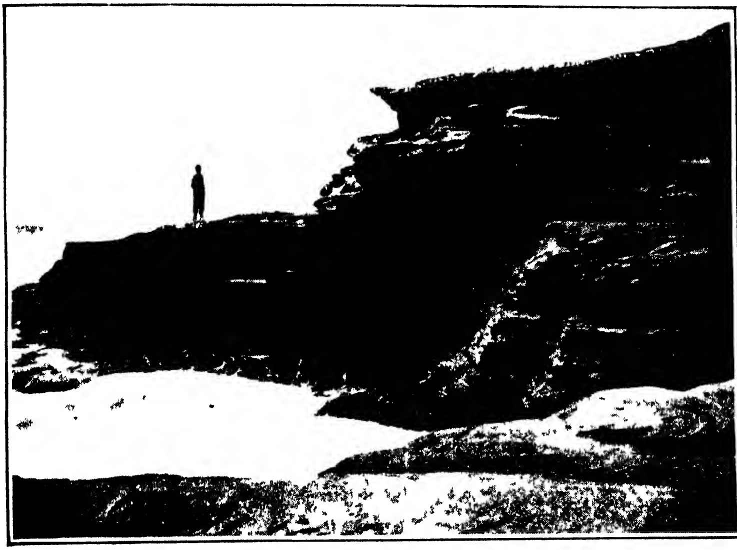


Fig 1

Fig. 2

Fig. 1.

Fig. 2.

A CONTRIBUTION TO THE GEOLOGY OF THE IRWIN RIVER VALLEY OF WESTERN AUSTRALIA.

By W. G. WOOLNOUGH, D.Sc., F.G.S., and
J. L. SOMERVILLE, B.Sc.

(With Plates III., IV., and V.)

(Read before the Royal Society of N.S. Wales, June 4, 1924.)

The investigations the results of which form the subject of this paper, were undertaken in the search for possible salt deposits on behalf of Messrs. Brunner, Mond and Company, Limited, of Northwich, England. The very specific objects of this search imposed many limitations upon the authors, and the exigencies of the service prevented them from completing many of the more purely scientific lines of investigation. The present paper is written more to stimulate research in this most fascinating region than as a full and complete description of the area. Our thanks are due to the Directors of the above company for their permission to publish the results obtained.

GEOGRAPHY.

The valley of the middle section of the Irwin River constitutes a remarkable element in the Physiography of Western Australia. The dominating feature of the South Western Division of the State is the Darling Peneplain, a plateau of very slight relief, with a remarkably uniform surface, 900 feet to 1200 feet above sea level, embracing the greater part of the land division referred to. In the immediate neighbourhood of Perth, the conspicuous escarpment which forms the western boundary of the

plateau faces the Swan Coastal Plain, which, about 20 miles wide, extends to the coast of the Indian Ocean. The well-marked linear escarpment typical of these southern areas is interrupted at Gin Gin, 50 miles north of Perth, by the intervention of transverse structures, probably faults, but the plateau continues without interruption far to the north of the latitude of Geraldton.

In the neighbourhood of the Irwin River, about 200 miles north of Perth, the western escarpment, while less commanding than it is near the capital, is still a conspicuous feature. In the south of the State the slopes are formed of granite and greenstone, while in the area under consideration the rocks are soft Jurassic (?) sandstones, a difference which is reflected in the more gentle slopes and the more dissected and embayed character of the declivity.

The town of Mingenew is situated in a depression of the plateau about 25 miles to the east of the escarpment, and at the southern end of a most remarkable, flat-floored valley, 30 miles long from north to south, by 9 miles wide from east to west (Plate IV.). This valley is completely surrounded by steep escarpments. In its southern portion it is fairly densely timbered with stunted trees, mostly "Jam" (*Acacia acuminata*), "Needle Bush" (*Hakea recurvata*), and "Curara" (*Hakea sp.*). Its northern portions, embracing some of the finest pastoral country in the State, is practically treeless; but bears a thick mantle of grass, "Salt Bush" and "Sago Bush" (*Kochia villosa*). The surrounding hills are more thickly covered with vegetation, including "Jam," "Needle Bush," Wattles (*Acacia doratoxylon* and *A. rostellifera*), "Mallee" (*Eucalyptus eudesmoides*), and "York Gum" (*E. foecunda var. loxophloeba*). The stream channels

carry "River Gum" (*E. rostrata*) and "Swamp Oak" (*Casuarina glauca*).

The northern end of the valley is drained by the north and south branches of the Irwin River, which, uniting almost as soon as they enter the valley proper, form the main stream which flows in a general south-westerly direction till it reaches Yarragadee (Plate IV.), where it turns sharply westwards and passes through the western plateau region in a deep narrow gorge.

The southern end of the valley is drained by the Lockier and its tributary, Green Brook. Like the Irwin. the Lockier leaves the valley by means of a rather narrow gorge; though the feature in this case is somewhat less pronounced than the Yarragadee gorge. Between the two streams there is a most inconspicuous divide, built up of alluvial material, very strongly suggestive of the existence of a lake in very recent geological time. This is merely a suggestion, as we have not had opportunity to verify the point.

The level of the valley floor is interrupted by a few hills, conspicuous by reason of the rarity of such features.

At the northern end of the basin are four comparatively large mesas, which we have numbered for convenience of reference (Plate III.) Close to Mesa No. 1 is the very striking butte, Gnoolawa Hill, a perfect cone formed by denudation of level bedded rocks of varying hardness. Bugalallie Hill, to the north of Nangetty Station, is a typical mesa-butte, and other similar features occur close to the escarpment along the southern and eastern sides of the valley. Two such hills, Mount Melara and Mount Budd, in the south-eastern corner of the valley, are conspicuous and useful landmarks.

Enanty Hill, just north of Mingenew, belongs to the same category. All these hills are residuals of the sand-

stone plateau which once covered the entire area, and are, geologically considered, outliers of the plateau-forming beds.

Quite distinct from the above, both in structure and outline, is the conspicuous group of three hills at Bacton Station, shown on the Government maps as Brockman Hills. These are inliers of ancient crystalline rocks similar to those which occur in mass in the neighbourhood of Yandanooka to the south, and which extend as a wedge-shaped "promontory" into the alluvials of the plain.

Climatically the area is characterised by low rainfall, the average annual precipitation amounting to about 15 inches, most of which falls between June and September. Both the "rivers" of the region flow only during the wet season, and become mere chains of pools, even these being very infrequent in the case of the Irwin, during the greater part of the year. The waters of the Lockier are more or less potable so long as they last; but those of the Irwin soon become intensely salt, and are unfit even for stock purposes.

Throughout the valley, domestic water supplies are obtained from roof catchments, while stock water is conserved in large excavated tanks, the clay soils possessing admirable holding capacity. Some of these tank supplies become unpleasantly brackish towards the end of the dry season. On the plateau surrounding the valley, deep wells in the soft sandstones yield practically unlimited supplies of excellent water. We are informed by Mr. Black, manager of Bacton Station, that four feet of water were obtained in one of the wells on the western "Sand Plain" at a depth of 152 feet, and that a sixteen-foot windmill, pumping continuously, failed to reduce the level appreciably.

On the slopes bounding the valley on the south a series of springs, the Eyragulla Springs, discharge about two miles east of the town of Mingenew. One of these has been opened up by the Midland Railway Co. and yields an ample supply of good water for locomotive purposes. The supply appears to be capable of almost indefinite expansion.

The very decided differences in salinity of the waters of the district are to be correlated with the distribution of the Permo-Carboniferous and Jurassic rocks, respectively.

GEOLOGICAL FORMATIONS.

Within the area examined by us there is very great variety in the geological formations developed.

Tentatively, we distinguish the following:—

Laterite and travertine	Cainozoic.
Plateau Beds	
Coastal Sands	
Valley Beds	
Porous Sandstones and Ferruginous Sandstones	Jurassic
Mingenew Beds	Permo-Carboniferous.
Upper Marine Beds	
Freshwater Series with Coal Seams	
Fossil Cliff Beds	
Olive Shales, very gypseous	
Gastrioceras Bed	
Buff Beds	
"Bull Paddock" Limestone	
Grey Limestones	
Spheroidal Marls	
Main Glacial Horizon	
Sub-glacial Beds	
Basal Grits and Boulder Clays	
Yandanooka Beds	Pre-Cambrian.
Gneisses and Schists	

The relations of these various formations have not been made out satisfactorily except in the case of the Permo-Carboniferous Beds occurring in the northern part of the valley.

PRE-CAMBRIAN.

Two portions of the area are occupied by formations of undoubted Pre-Cambrian age. The rocks of the Darling Peneplain, throughout almost its entire extent, are gneisses, schists, granites and gabbroid rocks. Similar types are met with throughout the whole of the Government Railway line from Wongan Hills to Mullewa, though exposures are comparatively infrequent. From just north of Gin Gin to Yandanooka on the Midland Company's line similar rocks dominate the geology.

One of us (W.G.W.), in the course of a single motor journey under very disadvantageous conditions, from Morowa on the Wongan Hills line to Mingenew, gained a few impressions of the geological features without being able to obtain any really satisfactory data. For some distance west of Morowa the normal crystalline rocks of the plateau persist. As the broken country to the east of the Irwin Valley is approached there is a considerable extent of reddish bedded rocks, perhaps tuffaceous, whose relations to the crystallines are unknown, but which are, almost certainly, to be correlated with the formation called the Yandanooka Beds in the above table. No limestones were seen.

Still further west, approaching Mount Melara, there are thick masses of level bedded sandstones, the gorges in which are reminiscent, on a small scale, of some of the gullies in the Blue Mountains of New South Wales. While the sandstones are to be referred to either the Plateau Beds or the Jurassic Series of the table, the crystalline rocks and the Red Beds are probably both of Pre-Cambrian age.

The rocks of Arrino and the surrounding district have been described by Campbell.*

The North Branch of the Upper Irwin River crosses the line of junction between the crystalline series and the Permo-Carboniferous about four miles above the Coal Seam. At this point the junction is undoubtedly marked by a heavy fault running N. 20° W. and S. 20° E. parallel to the schistosity of the gneisses, and therefore parallel to the main structural axis of Western Australia. The continuation of this fault line southwards has been traced most carefully by Campbell, and is shown on his map of the area.

The second area of Pre-Cambrian rocks in the district is almost completely isolated from the main mass by a tongue of Permo-Carboniferous rocks. It extends from the Midland Railway Line east of Yandanooka Station as a wedge jutting northwards (Plate IV.) This wedge-shaped mass is much more intimately associated with the subject of this paper than is the main plateau. The Yandanooka Estate, recently subdivided as a returned soldiers' settlement, includes the greater part of the Pre-Cambrian area.

Even the most cursory examination, which is all that we were able to give it, shows that there are two very distinct geological units included within the boundaries of the old rock mass.

On the western side, and extending from Yandanooka Railway Station in a north-north-westerly direction almost to Green Brook, is a range of rather high and very rugged hills, heavily forested, and culminating in Mullingarra Hill. These are composed of coarse biotite

*Campbell, W. D.—The Irwin River Coalfield. Bull. 38, Geol. Survey, Western Australia.

gneisses, granite, aplite and pegmatite, and large "hungry" quartz reefs. For purposes of convenience this backbone of crystalline rock may be termed the Mullingarra Axis. The Brockman Hills form an inlier representing the continuation of the same axis, separated from the main mass by the intervening stretch of alluvial formations. These hills consist of mica schists and hornblende granulites, with intrusive muscovite pegmatites, dipping N.W. at low angles.

The crystalline rocks of the Mullingarra Axis are of the same general type as those forming the bulk of the Darling Plateau, and are of extreme geological antiquity, probably Laurentian.

While considerably contorted and probably faulted, they have a general inclination towards the west at high angles.

Along the eastern side of the Mullingarra Axis, and resting with strong unconformity upon its component beds, there is a narrow but continuous belt of rocks of very great interest. These include crystalline magnesian limestones, and reddish to purplish tuffaceous (?) slates and quartzites interbedded with one another. Careful search failed to reveal any fossils.

This limestone is met with on the railway line to the east of Yandanooka Station, though it is not very conspicuous at that point. It is strongly developed at the road junction about a mile north-east of the railway station, and reaches its maximum development on the State Farm block some distance further to the north. It can be traced at least as far north as Green's block (No. 27 on the plan of the Yandanooka Subdivision).*

The purple slates contain much muscovite, probably derived from the rocks of the Mullingarra Axis: an ad-

*Government Lithograph of Yandanooka Estate.

ditional presumption for difference in age of the two Pre-Cambrian series.

Both limestones and red beds are *much* less intensely metamorphosed than are the rocks of the Mullingarra Axis, and are evidently much younger. On the other hand they are much more altered and jointed than the Permo-Carboniferous beds associated with them, and seem considerably older than the latter. Dipping, as they do, towards the east-north-east, at angles of from 20° to 35°, there is almost a right angle unconformity between them and the gneissic beds to the west. The unconformity between them and the Permo-Carboniferous is less striking. The latter beds dip in the same general direction as do the limestone series, but the angles of inclination are smaller. The steepest dips in the Permo-Carboniferous are less than 20°, while the gentlest dips in the older beds do not seem to fall below that figure. There is very little doubt, then, that a second unconformity may be postulated between the limestone-slate series and the Permo-Carboniferous.

It is important to note that both limestones and slates are intersected by broad pegmatite and aplite veins, and must therefore antedate the latest phases of granite injection in this part of Western Australia. One of us (W.G.W.)+ has suggested reasons for believing that the granites of this part of the continent are all Pre-Cambrian, or, at latest, Cambrian in age. If this is so, the Yandanooka Beds, as we may conveniently term the limestone-slate series, are probably of late Pre-Cambrian age. The apparent total absence of fossils in rocks quite well adapted for their preservation, while by no means a

+Woolnough, W. G.—A geological reconnaissance of the Stirling Ranges of Western Australia, Proc. Roy. Soc., N.S.W., Vol. LIV., 1920, p. 104.

proof of great age, is at least not unfavourable to the above theory. That they are older than Permo-Carboniferous is shown conclusively by the occurrence in the glacial beds of that system of boulders obviously derived from the formation in question. There are reasons for believing that these boulders have come from some occurrence of the Yandanooka Beds other than the area here referred to, perhaps from the continuation of the series on the plateau surface west of Morowa (see above) for there is no doubt as to the similarity of the rocks there described and those of Yandanooka.

Tentatively, then, an Upper Proterozoic age is assigned to the Yandanooka Beds, and the possibility of their correlation with the Nullagine Series* of the Pilbara Goldfield is suggested. Nothing even remotely suggestive of the Nullagine Conglomerate has been encountered anywhere within the district.

PERMO-CARBONIFEROUS.

The chief geological interest of the district centres in the Permo-Carboniferous System.† The most striking and conspicuous member of this system in the Irwin Valley is undoubtedly the Main Glacial Horizon, the equivalent of the Lyon's Conglomerate,‡ which is responsible for the principal topograhic features in the otherwise featureless basin. With this formation as a datum,

---

*Maitland, A. Gibb.—The geological features and mineral resources of the Pilbara Goldfield. Geol. Surv., W.A., Bull. 15, p. 120 (Reprint 1908).

† This term is here used in its older significance, as in Professor David's "Geology of the Hunter River Coal Measures", as the authors are strongly of opinion that, even if there is good palæontological reason for regarding the lower beds as Carboniferous and the upper as Permian, the formation as a whole is a distinct geological entity.

‡ Maitland, A. Gibb.—Relics of the Permo-Carboniferous Ice Age in Western Australia. Anniv. Address, Journ. Nat. Hist. Soc., W.A., Vol. IV., p. 8. 1911.

it is convenient to divide the associated horizons into subglacial and supra-glacial beds, respectively; for here, as in the *North-western Division, the Lyons Conglomerate* is not the basal bed of the system.

Basal Grits and Boulder Beds.

In certain places, for instance near the northern boundary of Henderson's block (No. 34 of the Yandanooka Subdivision), glacial boulder beds of undoubted Permo-Carboniferous age rest directly on the Yandanooka limestones and purple beds, and form the basal conglomerate of the series. Glaciated pavements were looked for without success. There is little doubt that such pavements would be discovered if the thinnest parts of the capping of glacial beds could be removed. It is somewhat doubtful, however, if the Yandanooka Beds are competent to retain glacial striæ on surfaces exposed to the intense temperature changes characteristic of this region.

A mile or two to the south, on Block No 21, the basal beds of the Permo-Carboniferous do not appear to be typically of glacial origin. Instead; there is a grit-breccia containing much quartz and felspar in angular fragments, and very strongly false-bedded. Its relation to the Main Glacial Horizon is unknown; probably the latter lies further to the east, and higher in the sequence.

Just behind Bacton House, on the slopes of the Brockman Hills, isolated glacial erratics are fairly plentiful, but the basement rocks, coarse, much decomposed schists and pegmatites, have not retained any glacial striæ, though the occurrence of the erratics points to the existence of a glacial bed resting directly on the crystalline pavement.

Sub-Glacial Beds.

For about five miles northwards from Brockman Hills stretches a level plain, devoid of outcrops, and hopeless

from a geological point of view. The sub-glacial beds of the system, which occupy this area, are evidently very soft and friable, and have weathered deeply. In addition, there seems reason to believe that there has been much *deposition of alluvial material in the mature valley* which stretches from the Lockier to the Irwin; if, indeed, there has not existed here, in very recent geological times, a definite lake area (see below).

Sub-glacial beds are slightly exposed in the banks of the Irwin just before it turns westward to leave the broad valley and plunge into the Yarragadee gorge, through which it traverses the "Jurassic" plateau which forms the western wall of the valley. Between the giant erratic known as "The White Horse" and the river channel, these sub-glacial beds are soft, dark grey and greenish shales, with thin lenticular bands of argillaceous limestone, yielding rich black soil, intensely sticky in wet weather, and very deeply cracked in dry seasons. No fossils have been found in these beds up to the present.

On the right bank of the river, immediately under the decided scarps formed by the Main Glacial Bed to the south-east of the Nangetty Woolshed, the sub-glacial beds are somewhat extensively exposed and consist of rather sandy green shales with a strong tendency to spheroidal disintegration.

In the extreme south-eastern corner of the area examined by us, that is, to the east of Yandanooka Soldiers' Settlement, a most interesting and important section of the sub-glacial beds needs far more detailed inspection than we were able to give it. Campbell's map*, even though he fails to indicate the continuity of the glacial bed, shows that the Main Glacial Horizon lies well to the east of the Yandanooka Beds.

*Loc. cit., Plate I., Sheet 2.

Main Glacial Horizon.

The distribution of the Main Glacial Horizon (Lyons Conglomerate) reveals clearly the structure of the entire Permo-Carboniferous System in the Irwin Valley, namely, that of a broad flat anticline, pitching very gently towards the north-north-west, and with its eastern limb dipping more steeply than the western one, which, in fact, is almost horizontal.

The Main Glacial Horizon is indicated on Campbell's map by the symbol C_1 and is shown to occur about five miles south-east of Yandanooka Railway Station. We have not visited this locality. The most southerly point at which we have definitely seen the bed is near the road at a point about three miles south-west of Mount Budd. From this point we have traced a practically continuous band of it to the point at which it enters our detailed map (Plate III.). The zone is *not*, as shown by Campbell, a series of isolated outcrops, but is continuous except for the interruptions caused by thin and very local patches of Valley Beds (see below).

Represented at first only by a lông line of glacial erratics scattered over a more or less sandy soil, the outcrop becomes more and more pronounced, until, near "The White Horse" it forms decided hills with gentle dip-slopes towards the east, and scarps 30 to 40 feet high towards the river valley on the west.

Facing these scarps across the river are still more striking hills with steep declivities towards the river, and gentle dip-slopes towards the west.

These features represent, respectively, the eastern and western limbs of the anticline above mentioned.

The river flows over the extreme tip of the pitching anticline, and its alluvials hide the outcrops there for a

short distance. These alluvials are not delineated on our map.

The map shows all the dips it has been possible to measure. Unfortunately, the softness of the rocks and consequent lack of exposures makes it all too difficult to obtain accurate measurements, especially as the inclination of the rocks is always slight, and there is a certain amount of "rolling." Dips measured on lenticles of limestone are not very trustworthy, as the friable nature of the associated beds favours undermining and local tilting of the limestone slabs.

The Main Glacial Horizon is a most typical example of a glacial boulder bed. Rocks of all shapes and sizes, and of a bewildering variety of petrological types are heaped together indiscriminately in a groundmass of tough clay or sandy material. Many of the erratics are most beautifully facetted and striated.

No census of rock varieties has been attempted. The most abundant types are granitic rocks of various kinds, particularly aplitic and pegmatitic varieties. Almost equally prominent are quartzites, amongst which are fine grained liver-coloured and purple ones of fine texture, passing into slaty types, strongly reminiscent of the red and purple members of the Yandanooka Beds above described.

Another very striking rock type is a grey limestone of fine crystalline texture, very much seamed with secondary silica. All stages of silication from incipient veining to complete replacement can be seen, illustrating very strikingly the exceedingly important part played by silication of limestone amongst the Pre-Cambrian formations of Australia. The limestone of these erratics is not of the type found *in situ* at Yandanooka. There is little doubt that it and the purple rocks come from an area similar to that

described; but where that area lies has not been determined at present.

Tourmaline is a notable mineral among the erratics and the nearest recorded locality for this mineral is Northampton*; but this area is very garnetiferous, and the erratics of the Irwin have not yielded any trace of this mineral. Some other area must be looked to for the origin of the tourmaline bearing erratics.

One of the most striking petrological types amongst the erratics, and one of the most remarkable we have ever seen, is a felspar porphyry with large stellate groups of felspar crystals. Of this rock only one example was found, near Urella Homestead.

Critical examination of the glacial conglomerate was beyond our province in the course of an economic investigation, but certain impressions gained may be of value to future workers in this most fascinating field.

The best exposures of the Main Glacial Horizon are met with along the telegraph lines and to the east of it, and extending from a point east of the Nangetty Woolshed on the north to a point east of Urella Homestead on the south. In some places within these limits there appear to be two fairly distinct zones of boulder clay separated by another zone in which erratics are but sparsely distributed. In other places, however, no such subdivision can be detected. At a point south-east of Nangetty Woolshed, on the edge of the escarpment overlooking the river, there is a considerable exposure of bedded tillite of a sandy nature, strongly cemented by carbonate of lime, and containing very few erratics. Similar exposures, mostly on a smaller scale, are met with at intervals, and it seems probable that large and small lenticles of tillite are interbedded in the main mass of boulder clay.

*Campbell Bull. 38, p.16.

At various places there is a very strong suggestion that small erratics have been "dumped" in heaps by the capsizing, or grounding and subsequent melting, of small, rock-laden ice floes. A similar phenomenon has been observed by one of us in the Upper Marine Permo-Carboniferous glacial beds of Jervis Bay, N.S.W.* Such grouping of erratics is apparent in the upper zones of the glacial horizon between Nangetty Woolshed and Bugallalie Hill.

Below the escarpment of the Main Glacial Horizon to the south-east of the Woolshed a somewhat similar grouping of small erratics is observable in the topmost layers of the sub-glacial beds. In this case, however, there is a strong suggestion that the stones have been gathered into depressions on the gently sloping surface by water action. It is quite possible, then, that the apparent grouping is everywhere an entirely secondary feature, and not a primary one, as is the case at Jervis Bay.

Some parts of the sandy tillite to the south-east of the Woolshed have the calcareous cement in crystal continuity over large areas, and therefore pass into Fontainebleau sandstones. Similar Fontainebleau sandstones occur just south of Bugallalie Hill, and between this point and Nangetty Homestead, in both instances apparently interbedded with the upper zones of the boulder clay.

Near the Woolshed there is a thin band of grey argillaceous limestone with rough cone-in-cone structure, which, also, is interbedded with the boulder clay.

Erratics of very large size are numerous and widely distributed through the Nangetty-Urella zone, though the

*David, T. W. E., and Taylor, T. G.—Occurrence of the pseudomorph glendonite in New South Wales, with notes on the microscopic and crystallographic characters by W. G. Woolnough and H. G. Foxall. Rec. Geol. Surv., N.S.W., 1905, Vol. VIII., pt. 2, pp. 161-179.

large ones are by no means confined to this area. Many of the blocks near Yandanooka are well over three feet in diameter. It is in the immediate neighbourhood of "The White Horse," however, that the largest blocks occur in the greatest abundance. As described by Campbell,* this giant erratic is 7 feet high by 18 feet by 13 feet, showing above the ground level. For about half a mile to the south of "The White Horse," gigantic blocks are piled together in long lines like unfinished railway embankments, and very vividly recall the true moraines of regions at present, or very recently, under glaciation. These moraine-like masses terminate very abruptly towards the south, in which direction level featureless plains extend without interruption to Bacton, at the foot of the Brockman Hills.

Either these rubble banks actually represent true moraines, laid bare in their original form by the denudation of the overlying marls; or, more probably there has been a certain amount of minor dip-faulting in this part of the basin. The question of faulting will be onsidered later.

It is noteworthy that, in these quasi-moraines, not only are the individual blocks of relatively large size, but the proportion of limestone fragments is unusually great. These very distinctive rocks become relatively and absolutely less abundant as we pass towards the north and west; suggesting that the ice moved from the south-east, as would be expected from the distribution of the Pre-Cambrian masses which undoubtedly constituted the gathering grounds for the ice during Permo-Carboniferous times.

While what we have termed the Main Glacial Horizon is a very well defined zone within the Permo-Carboniferous series, glacial erratics are by no means confined to it. The

---

*Campbell, W. D.—Loc. cit., p. 39.

probability of there being a distinct major glacial zone at the base of the system at Yandanooka has already been mentioned. In addition, erratic blocks are sparsely distributed throughout both the sub-glacial and the supra-glacial beds.

In the sub-glacial beds, between "The White Horse" and the river, boulders are somewhat frequent; but there is some doubt as to their being *in situ.* It is possible that much of the material may have been derived from the Main Glacial Horizon and redistributed in its present position during the erosion of the valley. Such an explanation can scarcely apply to the larger fragments, which are too large for water transport, and there is no reason why the whole of the material should not be *in situ.*

In the supra-glacial beds erratics become progressively less abundant as we pass upwards in the series. Scattered blocks, some of them of large size, are met with throughout the olive shales and gypseous shales; and occur even in the coal measures. Whether they persist among the Upper Marine Beds our observations do not permit us to say.

Spheroidal Marls.

(Included with the overlying Grey Limestones as "Grey Shales," in the map, Plate III.).

Immediately above the Main Glacial Horizon there is a series of light grey, highly calcareous shales or marls, remarkable for their spheroidal weathering, and for the abundance of calcareous concretions contained in them.

The smaller concretions simulate, to almost ludicrous perfection, the shapes of buns, pies, pasties and other culinary dainties. Many of them are only an inch or so in diameter, but the most abundant are those about three or four inches across. While some are almost globular, the majority are fairly flat. There is no limit in size, and the concretions pass by insensible gradations into lenticles of

limestone several feet in diameter, and these into quite extensive limestone beds. Simpson* has shown that the material of these marls and limestones is of almost ideal composition for the manufacture of Portland cement, without the addition of any other material. The smaller concretions are of practically uniform composition and texture throughout; but the larger ones are frequently septarian in structure. Many nodules have been broken in the hope of finding a recognisable organic nucleus, but without success. In most instances there does not appear to be any nucleus at all; in others, there are a few grains of sand.

Along with the development of considerable lateral dimensions there is a marked tendency for the material to exhibit cone-in-cone structure, which attains a very high degree of perfection in some bands. Even where cone-in-cone structure is not developed, the limestones tend to become markedly fibrous, with the fibres normal to the plane of deposition.

Without claiming to have studied the subjec deeply we are inclined to believe that the concretionary structures are secondary. The "meat-pie" and "Cornish pasty" shapes seem to be due to slightly different permeability of two adjacent shale bands, the concretion lying partly in one band, partly in the other.

The larger lenticles and limestone bands consist of material much more purely calcareous and less argillaceous than are the concretions, a distinction which probably exercises a determining influence on the development of cone-in-cone or fibrous structure, as opposed to concretionary. The larger limestone bands are certainly primary. At what stage, if any, the line between primary and secondary deposition is to be drawn will provide material for a most interesting research.

*Campbell, W. D.—Loc. cit., p. 45.

The spheroidal weathering of these marls is another very conspicuous feature. So readily does the material disintegrate on exposure that outcrops are very limited in distribution and extent. They occur only in creek banks where much undercutting is in progress. The best exposures are to be met with in the creek near Urella, and in Mullewa Creek northwards from Nangetty.

Grey Limestones.

By gradual increase in the relative proportion of limestone the spheroidal marls pass upwards, without any definite line of demarcation, into the grey limestones. These have the fibrous or cone-in-cone structure described above for the limestone bands in the marls. The texture is always fine, though there is sometimes a notable amount of secondary crystalline calcite in them. The individual beds are very lenticular in character and fail to show any great persistence. It is somewhat doubtful whether these beds should be separated from the spheroidal marls, but the differences seem sufficiently pronounced to call for comment.

Bull Paddock Limestone.

At the top of the grey limestones a fairly persistent horizon is defined by a band of limestone, or, more correctly, by a zone characterized by very considerable limestone lenticles. Nowhere is this band of any great thickness, probably not more than about five feet at most (the thickness is exaggerated on the map), and it is extremely doubtful whether the various outcrops form a continuous stratum. It is characteristic of the calcareous layers throughout the entire system that they thin out laterally and constitute mere lenses of rock material. All round the valley, however, one encounters fairly persistent outcrops of limestone at or about the same geological horizon, and, for this reason, a separate name has been

suggested for the bed or beds in question. A well defined outcrop occurs at the western side of the Nangetty bull-paddock, hence the name.

Buff Beds.

Not only does the Bull Paddock Limestone constitute a fairly persistent horizon, but it marks a transition point in the sequence of sedimentation. Below it the calcareous beds are grey in colour; above it they become decidedly yellowish; at first a light buff, but progressively darker in tint, until the colour becomes almost orange. This change is of course, due to an increase in the amount of iron carbonate precipitated along with the calcium carbonate. In other respects there is not much difference between the buff beds and the grey ones underneath the Bull Paddock Limestone. We have distinguished this zone as the Buff Beds.

Their upper limit is marked by another rather persistent limestone horizon, sufficiently thick and solid in places to give rise to a very decided scarp and hill feature. This is particularly the case in the north-eastern part of the valley, from Holmwood towards Gnoolawa. The limestone horizons are shown by the same symbol on the map. Their positions, in relation to the other beds, readily distinguish them from one another (Plate III.).

Gastrioceras Bed.

Immediately below the limestone band just mentioned is a narrow zone, scarcely to be dignified by the name of a bed, which is nevertheless one of the most persistent, readily recognised and important horizons in the entire series. The bed in question is never more than about 6 inches in thickness, but it contains abundant and well preserved specimens of *Gastrioceras*, replaced by siderite and silica. These are met with up to about 9 inches in diameter, but range mostly from three to six inches. So

highly characteristic is the rich orange band in which these fossils occur, that one soon comes to recognise it at first sight, and a brief search is sure to be rewarded by the discovery of numerous, well-preserved cephalopods. This extraordinarily narrow zone is the only one in which this particular fossil occurs, so that its occurrence is of inestimable value in field work. We have seen or heard of only two individuals which were not obtained directly from it. One of these was found by Mr. Eckermann, of Nangetty Station, to the north of Bugallalie Hill. We have referred the pebbly beds here to the Valley Beds, and have no doubt that the fossil is a "derived" one, deposited as a pebble in the position in which Mr. Eckermann found it. The other example was found by us to the south-west of Mesa No. 2, under conditions which left no doubt as to its having been dropped there by human agency since the last rain. Such an occurrence was extremely probable, as the stockmen and others were so much interested in our work that they examined and brought to us any fragment which, to their sharp eyes, appeared unusual or remarkable.

Olive Shales.

As stated above, the limestone horizon overlying the Gastrioceras bed marks the summit of the Buff Beds. At this point the character of the sedimentation underwent a revolution. The dominantly calcareous muds of the preceding cycle are replaced by much more argillaceous material, though even this is quite notably calcareous. These succeeding beds we have called the Olive Shales, on account of their characteristic colour in the very few exposures that are available.

So readily do these beds disintegrate that they are scarcely to be observed *in situ,* except in places where quite recent landslips have occurred. They weather to deep black soils, sticky in wet weather, and very like those

formed from the sub-glacial beds. Numerous limestone lenticles are interbedded with the olive shales, and their outcrops enable one to determine approximately the dips in areas which would otherwise be featureless.

The Olive Shales are much the thickest individual member of the Permo-Carboniferous System in the Irwin Valley. While rolls, folds and faults occur in such a way as to lead to excessive estimates of the thickness, it seems probable that they must reach at least 1,100 feet. In the dry season the area occupied by them becomes seamed with deep suncracks, particularly in the lower part of the stage. These deep suncracks are connected with a well marked development of underground drainage systems, especially near the river terraces. Such channels may extend for several hundred yards, before they merge into deep V shaped gutters at the edge of the terraces. Miniature "bad land" erosion is another feature that is extremely well shown in these Olive Shales. This is due largely to the presence of a somewhat hardened surface overlying the soft, easily eroded beds.

Throughout their entire thickness they are characterised by the occurrence in them of gypsum, more or less abundantly distributed. This mineral is most pronounced in the upper portions of the Olive Shales. In the banks of the Irwin, just below the point where it debouches from the gorge after the union of its two headwater branches, continuous sheets of pure transparent selenite up to two feet in length lie in the planes of bedding of the shales. The gypsum plates are also present as a filling in vertical joints. Gypsum may also surround limestone lenticles, the gypsum fibres being normal to the external surface of the lenticle. It may also impregnate a ball of clay so that it is in crystal continuity throughout; being comparable to the calcite in a Fontainebleau sandstone. These plates

are very thin, never more than about half an inch, yet they stand out a foot or more from the steep banks of the river and its tributary gullies. In some places the rock is estimated to contain from 20 to 25 per cent. of gypsum. The selenite slabs show a rudely radiating structure, which makes them too fragile to stand much transport. In its present condition the gypsum is almost certainly secondarily deposited, though the original material was probably in the form of connate salt in the beds. If such is the correct explanation, it follows that the water in which the muds were laid down was more saline than normal sea water, and was subject to heavy evaporation. As noted above, the waters derived from the Permo-Carboniferous beds are all more or less saline, and nowhere is this salinity more marked than in the area occupied by the Olive Shales. It is quite difficult to conserve supplies of water sufficiently fresh for stock purposes in this part of the valley. While the salinity of the water was sufficient to cause precipitation of a certain amount of the gypsum of the original sea water, it does not appear to have attained the much higher degree of concentration necessary to bring about the precipitation of salt.

It will be noted from the map (Plate III.) that, at a point 220 chains south-east from Gnoolawa Hill, there is a very local, but quite decided, disturbance in the structure of the basin.. It is just possible that this may be connected with the local concentration, or local removal, of soluble mineral matter. With this one possible exception, no strong indication of the presence of rock salt in mass was discovered, though the abundance of very saline waters in bores and wells suggests that salt is widely distributed in much larger quantities than is usually the case amongst the sedimentary formations of Australia. It is noteworthy that efflorescences of salt occur under overhanging ledges immediately

to the north of the disturbed area. Abundant salt also occurs in caves in the eastern escarpment of the valley, about 10 miles east of Yandanooka.

Occasional erratics, some of them of considerable dimensions, occur in the Olive Shales, and the possibility of disturbance of bedding by grounding icebergs must be borne in mind. The disturbance does not appear to be of this type, and is probably too extensive to be accounted for in this way. It is most likely an ordinary fold, and not due to soluble minerals.

Fossil Cliff Beds.

After the deposition of the Olive Shales another change in the conditions of sedimentation occurred. The sea found its way into the basin, normal conditions of salinity returned, and a richly fossiliferous zone of sediments was deposited. These include thin beds of pure marine limestone, as well as fossiliferous arenaceous beds.

These rocks are best seen at a point on the North Branch of the Irwin known as Fossil Cliff, and we have therefore designated the zone as the Fossil Cliff Beds These are included with the Olive Shales on the map.

In a north-north-westerly direction the fossiliferous beds disappear beneath the sand-plain, and do not reappear within the area examined by us. Towards the south-south-east, however, we have traced the continuation of the horizon for a considerable distance, and have recorded it in places not previously mentioned.

In the South Branch of the Irwin, at a point immediately to the west of the outcrop of the first (lowest) coal seam, an outcrop of fossiliferous marine beds occurs. Here, however, there is no trace of the limestone horizon, which suggests that the calcareous beds were deposited in isolated small pools of clear sea water. At the point in question the rocks are soft kaolinised sandstones, containing notable

quantities of jarosite. The only fossil obtained here was the hinge portion of an *Aviculopecten*. Unfortunately, the rock is so friable that it was impossible to preserve the specimen for palæontological examination. The relation of the bed to the overlying coal measures is so clearly the same as is the case at Fossil Cliff, that there is no doubt as to the identity of the horizon.

At a point 115 chains north-east of Holmwood Homestead, two thin bands of pure blue limestone rich in fossils occur in association with arenaceous and argillaceous beds. Again, there is practically no doubt as to the identity of the horizon with that of Fossil Cliff, though the included fossils are not exactly the same in the two cases. This bed is very close to the escarpment which bounds the eastern side of the valley, and the gullies have not been excavated sufficiently deeply to expose the overlying coal measures. For the same reason no further outcrop of the fossil bed itself is found to the south-east. It is likely that careful search may bring to light its extension in some of the more deeply eroded valleys in the direction of Mount Melara. So far as we are aware, these valleys have never been critically examined with this specific object. In any case, the extension in this direction must be strictly limited, as the main fault which bounds the Permo-Carboniferous rocks on the east is at no great distance.

The limestones of this phase, while pure, are of far too limited thickness to be of commercial value.

Coal Measures.

Immediately upstream from Fossil Cliff there are coal seams which have been the object of much interest in the district for many years.*

In the North Branch of the Irwin three seams are exposed. Of these the two upper ones were visible at the

*Campbell, W. D.—Loc. cit., p. 45.

time of Campbell's investigation, and were fully described by him. Both have been prospected to some extent, and sections of them can be seen in shallow shafts and tunnels. In no case are the excavations sufficiently deep to have penetrated beyond the limits of weathering and to have reached unaltered coal.

A third seam was exposed in the bed of the river at the time of our examination. This exposure was probably not available at the time of Campbell's visit: it certainly was not so at the times the locality was visited by one of us (W.G.W.) in 1913 and 1914. We were informed by local residents that the heavy flood of 1917 was responsible for the uncovering of this, probably the best seam in the locality. It is obvious from careful measurements that this seam is not visible at all in the cliff forming the left bank of the river, a fact which indicates that it is pure coal and free from a high percentage of ash. This has caused it to weather away completely at the outcrop. The section as we saw it in the bed of the river was 23 yards wide, on a bearing N. 55 degrees E. The dip being due east at 10 degrees, the deduced thickness of the seam is 7.2 feet. Obviously the seam in question must be extremely local in its development, as no coal of similar dimensions has been encountered in any of the bores. Our measurements, however, were perfectly definite.

In the South Branch of the Irwin three seams are exposed, though only one of them is of noteworthy dimensions. The lowest is represented by a black band about nine inches thick in white porous sandstones.

Twenty-seven feet higher, is a second seam about four feet thick as seen in the river bank. The upper two feet are clean coal, the lower half contains more band than coal. On these two seams several small trial shafts have been sunk, but none of them were accessible at the time

of our visit. The roof and floor of the middle seam are of white, porous sandstone, so that the seam would probably be very wet at a depth and difficult to work, even if the coal were otherwise worth exploiting.

One hundred and ten feet higher in the section is a very thin carbonaceous seam associated with a salt spring.

As stated above, no sign of coal measures was met with in their appropriate relation to the Fossil Cliff Beds to the north-east of Holmwood, probably because the erosion of the scarp is insufficient to expose them.

Campbell's map shows "Bituminous Seams" on Loc. 1909, about three miles south-east of Mount Budd; these are very probably the continuations of the seams of the northern part of the valley.

Up to the present none of the prospects seem to be at all promising. Everything points to the seams being thin, lenticular, variable in composition and of very local development. No sign of underclay is to be detected, and the strong probability is that the seams are of drift origin.

That strong currents in shallow water were effective in the deposition of the associated arenaceous sediments is shown by the occurrence of a band of strongly ripple-marked ferruginous sandstone, between the upper and middle seams of the South Branch, and by similar features in the sandstones overlying the coal seams in the North Branch. The predominance of sandy beds in association with the coal also suggests considerable activity in water transport. In the sandstones above the coal seams there are numerous erratic blocks which have clearly been "dumped" from some considerable height. One such fragment of decomposed gneiss, measuring 15 inches by 10 inches, occurs near the eastern end of the steep bank east of the coal seams in the South Branch. Another still larger boulder, observed by one of us (W.G.W.), and a party of

students in 1913 has since disappeared as the result of a landslip. Another excellent example occurs in the right bank of the North Branch some distance above the coal outcrops. It is a block of decomposed granite 16 inches in diameter. In all cases the underlying beds show distinct downward bending as the result of the impact of the boulder upon them while still soft and unconsolidated. In the vicinity of the last mentioned erratic the overlying beds have been contorted probably by the grounding of an ice floe.

It has been suggested to us that we may have mistaken some of the abundant ferruginous concretions in these beds for "dumped blocks," but this is not the case. Dumped blocks are quite familiar to us in the Permo-Carboniferous rocks of the Hunter River District of New South Wales. Also the rocks in question in the Irwin Valley are definite erratics of crystalline rocks derived from the Pre-Cambrian areas to the east.

At what appears to be the extreme base of the coal measures, there is a bed of intensely red sandstone, some four feet in thickness, which is strongly saliferous. The outcrop of this bed is very salt to the taste, and boulders, easily recognised as derived from it, occurring for some distance downstream, are superficially white from the salt incrustation. Between the outcrop of the red bed and that of the Fossil Cliff bed there are several perennial salt pools in the river, fed by springs. The water* in these pools is saline and acid; totally unfit for stock.

It would appear that the marine conditions evidenced by the deposition of the Fossil Cliff Beds gave place to subaerial conditions at the beginning of coal measure time; areas of sea water being isolated in the process. By complete evaporation these salt marshes produced the salt

*Campbell, W. D.—Loc. cit., p. 73.

mentioned. Later, the area was occupied by freshwater lakes into which were carried sands and vegetable matter. Occasional large blocks of rock were rafted into these lakes, possibly by floating trees, but far more probably by small floes of river ice. It is to be remembered that undoubted glacial erratics, up to three feet in diameter, are sporadically distributed through the Olive Shales which immediately underlie the Fossil Cliff Beds.

We have not been able to find any trace of the fault suggested by Woodward as being possibly present between the marine and freshwater series. The differences in dip between the two sets of beds is no greater than those differences in undoubtedly conformable portions of a series in which minor rolling is of such frequent occurrence.

The total thickness of the freshwater beds is quite inconsiderable; we estimate it at about 420 feet; though our measurements are by no means complete, owing to the relative inaccessibility of the place.*

Upper Marine Beds.

Above the coal measures there is a considerable thickness of black and olive shales, very similar to those developed in the upper part of the Olive Shale stage. Though we have not had an opportunity to examine these beds closely, the impression is that they, like the lower Olive Shales, are of marine origin.

Mingenew Beds.

About two miles east of Mingenew, at the southern end of the valley, there are, or rather there were, insignificant outcrops of ferruginous sandstone crowded with well defined casts of marine fossils of great variety. These have

*We were driven back to our main camp by reason of a sudden flood, caused by a heavy thunderstorm, and were unable to return to the examination of the upper reaches of the North Branch as we had intended.

been called the Mingenew Beds.* So small were these outcrops that they have been completely demolished in the search for fossils, and future observers may have difficulty in locating the exact spot. Their relationship to the remaining beds of the system is unknown, but, from palæontological considerations, it would appear that the facies of their fossils is distinctly more modern than that of the Fossil Cliff Beds.

Immediately to the north of the fossiliferous sandstones there are thick beds of ferruginous sandstone, apparently barren of fossils, dipping sharply northwards. This steep dip is certainly associated with the faulting which has occurred at the southern end of the valley. The spot in question is very close to the line of the major fault, which has defined the western side of the valley, and we are strongly of opinion that considerable cross faulting has taken place here also.

Close to the outcrop of the fossiliferous bed there are several masses of saccharoidal quartzite, standing as conspicuous bluffs completely isolated from any other rocks of the same kind. They remind one forcibly of the isolated masses of quartzite common in some places amongst the Cambrian and Pre-Cambrian limestones of Australia, which are due to replacement of the limestones by silica. Such an origin is improbable in this case. Neither does it seem likely that they are inliers of older rocks. It is most likely that they are of the nature of fault-rock formed by the alteration and comminution of the wall rocks along the actual fault plane. Much very interesting and important research remains to be done along this southern part of the valley.

JURASSIC.

Rocks of undoubted Mesozoic age are developed on the south-western slopes of the valley, about three miles north

*Campbell, W. D.—Bull. 38, Geol. Surv., W.A., p. 55.

of Mingenew. On the property of Mr. Wells, there is an extensive development of coarse ferruginous sandstones, with abundant well-preserved impressions of *Otozamites*. These have been examined by Dr. Walkom,* and he pronounces the formation to be of Jurassic age, and homotaxial with the Walloon Series of Queensland. The beds in question appear to be absolutely horizontal, while the Permo-Carboniferous beds in the immediate vicinity have quite pronounced dips. We have found no section where the two formations are in absolute contact, but the structural discordance is sufficiently strong to indicate a decided unconformity.

CAINOZOIC.

Plateau Beds.

To the west, the ferruginous beds disappear underneath soft whitish sandstones, horizontally disposed. These occupy large areas, and have always been regarded as belonging to the same series as the plant beds, and have therefore been indicated on Campbell's map as Jurassic. The widely distributed sandy beds on the eastern side of the valley have been similarly interpreted. These sandstones everywhere give rise to "Sand-plains," which occupy hundreds of square miles in this part of the State. Owing to the difficulties we have encountered in attempting to reconcile the distribution of these Sand-plains with the geological structures observed, we have been forced to the conclusion that the white sandstones of the Sand-plains are *not* of Jurassic age, but represent a more recent formation. For this widely extended formation we suggest the name of Plateau Beds.

We are led to this rather radical conclusion by the following considerations:—

*Walkom, A. B.—On the occurrence of Otozamites in Australia, with descriptions of specimens from Western Australia. Proc. Linn. Soc., N.S.W., XLVI., 1921, pp. 147-153.

(1) The white sandstones extend far to the east of the Post-Mesozoic fault which we claim to have recognised on the western scarp of the valley, and their distribution appears to be entirely independent of it.

(2) No fossils of Jurassic age have been found in these beds in any other part of the valley, so far as we know.

(3) The character of the beds changes in different places, and seems to reflect the nature of the underlying formations. Thus, on the four mesas, where the Permo-Carboniferous rocks are predominantly argillaceous, the Plateau Beds are argillaceous, and contain a considerable amount of hydrated silica in the form of common opal and porcellanite. Towards the south-eastern limits of the valley, where the underlying beds are saliferous, the sandstones are also strongly saliferous, and quite considerable deposits of salt occur under some of the ledges.

We therefore suggest that the Plateau Beds are formed of residual material, deposited *on the surface of an almost perfect peneplain,* during a period when mechanical transport was reduced to a negligible amount by the almost absolute horizontality of a land surface reduced to the base-level of erosion. They are thus the equivalents of the "laterites" of the Darling Plateau,* or, at all events, have a somewhat similar origin. The hydrated silica is believed to have been concentrated in the surface layers of the soil, as a result of the annual solution of material from the deeply rotted subsoil during winter (the wet season), and its transportation to the surface by capillarity

*Simpson, E. S.—Laterite in Western Australia. Geol. Mag., Dec. v., Vol. IX., 1912, pp. 339-406.

Woolnough, W. G.—The physiographic significance of laterite in Western Australia. Geol. Mag., Dec. vi., Vol. V., 1918, pp. 385-398.

Woolnough, W. G.—The Darling Peneplain of Western Australia. Proc. Roy. Soc., N.S.W., Vol. LII., 1919, pp. 385-396.

during the succeeding dry summer. Where the bed rocks are of igneous and metamorphic types, the precipitated material is aluminous or ferruginous, that is, lateritic; and the relatively strong resistance of the parent rock to disintegration, prevents the contamination of the chemically precipitated rock with any large proportion of arenaceous material. Where, however, the bed rock consists of argillaceous marine sediments, and perhaps contains a proportion of siliceous organic matter, the surface rock becomes porcellanised. Where, again, the bed rock is sandstone, as in the case of the Jurassic areas, the Plateau Beds become pure sandstones.

If this suggestion stands the test of future observations, we believe it will explain many points in the geology of Western Australia which are at present somewhat obscure.

We have not been able to apply the results of this theory to the sandy beds on the east of the Irwin Valley, for the distribution of which, we have simply accepted the boundaries given by Campbell. His map shows a very sharp line of demarcation between the crystalline rocks of the Plateau, and the beds indicated by him as Jurassic. This line is coincident with that which separates Pre-Cambrian and Permo-Carboniferous where they come into contact, a feature which must be due to something more than coincidence. It must be due either to a renewal of the faulting along the old main axis since the deposition of the Plateau Beds, or to the fact that the deposition of the latter has been so purely selective, that they eschew the crystalline bed rock areas completely, and that they are represented thereon, by the more familiar type of laterite. We strongly incline to the latter supposition.

On this theory, the Plateau Beds once covered the entire area now occupied by the Irwin Valley; and they have been almost completely removed by erosion within the

limits of the valley itself. This suggests a very considerable age for the beds.*

Valley Beds.

Strictly confined within the limits of the valley itself, is a widespread formation whose indentity does not seem to have been appreciated previously. Over wide areas the Palæozoic rocks are hidden by coarse-grained pebbly sediments, conglomerates in parts, breccias in others. In many places they so closely resemble the finer portions of the glacial formations, that it is a little difficult to distinguish between the two, especially as the newer beds represent only slightly redistributed material derived from the older ones. From the fact that these beds lie at somewhat different altitudes in different parts of the valley, it is believed that they are piedmont beds developed at the foot of the valley scarp under subaerial conditions. Another possible explanation should be borne in mind and critically examined by future investigators, namely, that the various levels may actually be portions of different horizontal sheets of gravel, each sheet representing the flood plain formed at a particular stage of the river's history, or a *lake* terrace built up during a period of temporary stability while the progressive draining of a lake, through the erosion of its outlet, was in progress. In support of this latter theory, it may be noted that the largest continuous areas of what we term the Valley Beds are practically level. This is the case with the very extensive belt which fringes the floor of the valley on its eastern side, about White Hills, and the almost equally extensive areas on the west of the valley south of Urella. The large patch near

*Jutson, J. T.—An outline of the Physiographic Geology (Physiography) of Western Australia, Bull. 61, Geol. Survey, Western Australia, p. 96, 1914.

Woolnough, W. G.—The Darling Peneplain of Western Australia. Proc. Roy. Soc., N.S.W., Vol. LII., p. 393, 1919.

Bugalallie Hill and that near the entrance to the Upper Irwin Gorge, are more like piedmont formations. Our map does not attempt a complete delimitation of these beds, a problem which will undoubtedly be productive of valuable results, in the hands of some future investigator.

Comparatively recent as these beds are in a geological sense, the fact that they have suffered extensive erosion, and now stand as scarps above the river bank south of Urella, shows that they are, nevertheless, of considerable antiquity. The strong probability of their containing remains of extinct marsupials, should tempt someone to devote special attention to them, although we were unsuccessful in finding such remains.

Under whatever conditions they were accumulated, it is evident that large quantities of water were directly involved in their formation, and that they are probably to be referred to some part of the pluvial epoch which seems to have preceded the existing climatic cycle in Australia.

Coastal Sands, Laterite and Travertine.

Widespread and important as these formations are, they scarcely come within the scope of the present paper. They are similar in all respects to the formations which build up the entire coastal plain, extending from Geographe Bay on the south, to beyond Geraldton on the north. Composed largely of sand dunes of greater or less age, they have been formed chiefly of beach sand containing a considerable proportion of calcareous material. Some of the dunes in the neighbourhood of Dongara, for instance, consist of almost pure calcium carbonate.*

Naturally, then, under the existing climatic conditions of annual alternation of dry and wet seasons, there has

*Ann. Progress Report of the Geological Survey of W.A. for 1915 (Perth, 1916).

been an extensive development of almost pure travertine, locally termed "capstone." This is used to some extent as a building stone, and for the manufacture of lime for building and agricultural purposes.

In the inter-dune hollows near Dongara, there are deposits of gypsum of economic value.

The presence of a small upraised coral reef at Point Leander, Dongara, lifted at least twenty to thirty feet above sea level, is a positive proof of very recent uplift of the land, corresponding with that described by one of us (J.L.S.), in the valley of the Swan River, near Perth*.

The laterite which is developed in patches all over the high lands, is of normal Western Australian type, and need not be described in detail in this communication. It is noteworthy that the laterite developed on top of the sandy "Jurassic" or Plateau Beds is extremely sandy; passing, in fact, into ferruginous sandstone. The problem of the distribution and altitudes of the laterite remnants at the southern end of the valley, is certainly connected with the probably complicated faulting which has taken place in this part of the district, and must be left for future observers to solve.

FAULTS.

While Campbell does not specifically state the fact, his map and descriptions show conclusively, that there is certainly a heavy fault at the boundary between the Pre-Cambrian plateau on the east, and the sedimentary Irwin River Valley on the west. The throw of this fault is towards the west, that is, from the continent, towards the Indian Ocean. Its amount is unknown, but it is certainly very considerable, being of the order of *at least* the total

*Somerville, J. L.—Evidences of uplift in the neighbourhood of Perth. Journ. and Proc. Roy. Soc., W.A., Vol. VI., pt. 1, p. 5.

thickness of the Permo-Carboniferous System as developed in this area.

That it probably increases from south to north, is suggested by the pitching of the Permo-Carboniferous beds in that direction, and by the occurrence and shape of the Mullingarra-Yandanooka Pre-Cambrian complex to the west of the fault line.

We maintain that we have established the proof of the existence of another equally important fault, almost parallel to the above, on the western side of the valley. It is with regard to this side of the valley that our map differs most markedly from that of Campbell. The latter shows a promontory of Jurassic rocks extending eastwards into the valley, about half way between Mingenew and Yarragadee. He shows also, a deep narrow bay of Permo-Carboniferous rocks extending down the river channel to the west. The idea of a fault having occurred to us, we examined these points critically, and we conclude that the "Jurassic" promontory is to be explained as an extension of the post-fault Plateau and valley beds. The mapping of the alluvials of the lower Irwin as Permo-Carboniferous was a most natural mistake, seeing that the easily disintegrated marine beds do not produce outcrops, while the alluvials, derived directly from them, give rise to soils of practically identical character.

A definite proof of the faulting postulated, is supplied by the evidence of two bores put down near Urella Homestead by Mr. Darlot. One of these, situated about two hundred yards north of the homestead, is 497 feet deep. It passed through saliferous "blue clays" of Permo-Carboniferous age, all the way. The other, on the edge of the "sandplain" half a mile to the west, reached 507 feet in soft sandstone, all the way. "Coal" was reported at the bottom. These sandstones are certainly Jurassic. Even

allowing for the difference in altitude of the surface at the two bore sites, only an abnormally steep dip could depress the Permo-Carboniferous "blue clays" below the bottom of the second bore. In the meagre sections available, there is no evidence of such a steep dip; on the contrary, the beds are almost horizontal.

On the sand plain to the west of Nangetty, there are several springs and wells which afford corroborative evidence as to the existence of the fault. Nangade Spring, situated almost exactly on the line of fracture, gives a constant supply of fresh water, and forms a permanent marshy area. It is comparable with Eyragulla Springs, east of Mingenew. To the south-east of Nangade Spring there is a claypan filled with salt water during the wet season, but covered with a crust of salt when we saw it. Still further south is a well and windmill yielding water fit for stock, but not for human consumption, during most seasons. In anything like a dry season, the water of this well becomes too salt even for stock. We interpret these differences as depending on the nature of the bedrock, waters derived from the Jurassic being fresh and abundant, those derived from the Permo-Carboniferous being relatively scanty and saline. The case of the Bacton "Sand Plain Well" has already been referred to.

Between the wells referred to and Urella, one of the most conspicuous "capes" on the escarpment has its eastern point of Permo-Carboniferous clay, while the rear (western) portion consists of sandy Jurassic (?) beds.

Producing southwards the straight line defined by these various points, we find that the fault passes just to the west of Enanty Hill, and very close to the outcrop of the Mingenew beds. A single marine fossil was found at Enanty Hill. Eyragulla Springs lie just to the south-west of this line, which, further on, passes through some abnormal rock

exposures to the south of a prominent laterite bluff on the Yandanooka Road, and crosses the railway line close to Yandanooka Station. Thence onwards we have not followed it. The boundary between "Jurassic" and granitic rocks, as given by Campbell, runs almost due south from Yandanooka. This suggests that the fault must end very near the latter place, or that it must curve sharply southwards where it encounters the granite. We consider these criteria amply sufficient to establish the existence of the fault postulated.

The degree of certainty is much less in the case of the third major fault indicated in the section (Plate V.). Even here, however, we believe that there is a strong presumption in favour of its existence. As stated above, the escarpment which overlooks the coastal plains of Dongara, Walkaway and Geraldton, while it is a very decided and conspicuous feature, is much more dissected and embayed than is the similar escarpment overlooking the Swan Coastal Plain at Perth. This distinction may well be due to the difference in resistance to erosion of the Plateau rocks in the two places. The similarity in other respects is so striking, that the assumption of a similar origin for the two structures is by no means unreasonable. We are convinced that the escarpment of the Darling Range at Perth cannot be explained otherwise than as a major fault scarp, extending for at least 200 miles without a break. We therefore confidently suggest the existence of a similar fault to account for what may conveniently be termed the Moonyoonooka Scarp, from the name of the railway station which is situated at its foot, on the Geraldton-Mullewa line. In the railway section at this point the sudden passage from the sands of the coastal plain to the granites underlying the plateau, is almost as striking as it is to the east of Perth. The difference is that at Moonyoonooka the granites are covered by almost level-bedded marine Jurassic rocks,

which contain a wonderful assemblage of fossils. There is very little doubt as to the existence of the fault at Moonyoonooka, and its extension southwards is an eminently reasonable assumption, even though the evidence of its existence at the point where the actual line of section crosses it, is not of a very conclusive nature.

The strong probability of the existence of a series of major step-faults throwing towards the Indian Ocean, is therefore reasonably well established.

In this connection it may be mentioned that, at "The Nineteen Mile," between Geraldton and Mullewa, there are two small faults of about six feet displacement, throwing the fossiliferous Jurassic strata towards the west, thus repeating, on a very small scale, the major structure suggested for the district.

In addition to the major strike faults of the Irwin Valley, several minor dislocations have been observed.

A small dip fault with a throw of twelve feet, passes through the Buff Beds two miles south of Urella.

The abrupt termination of the psuedo-moraines south of "The White Horse" may be due to another dip fault, though the evidence is inconclusive.

In the same neighbourhood the forms of the small scarps of the Main Glacial Horizon on the east and west, respectively, of the valley in which lies "The White Horse," indicate a strike fault with a throw towards the west of about fifty feet. It is noteworthy that Campbell shows abnormally steep dips in this particular area. These we have not been able to find.

FOSSILS.

The palæontology of the region has received a good deal of attention in the past. We have collected as fully as was possible in the very limited time at our disposal for

this purpose, but our collections have not yet received detailed palæontological examination.

SUMMARY OF CONCLUSIONS.

Two distinct Pre-Cambrian formations are represented in the Irwin River District. The older, probably Laurentian, Mullingarra Beds; and the newer, probably Upper Proterozoic, Yandanooka Beds, with a strong unconformity between them.

Permo-Carboniferous Beds rest on the Pre-Cambrian basement unconformably. A detailed account of the stratigraphy of these beds is given. The most noteworthy features are:—

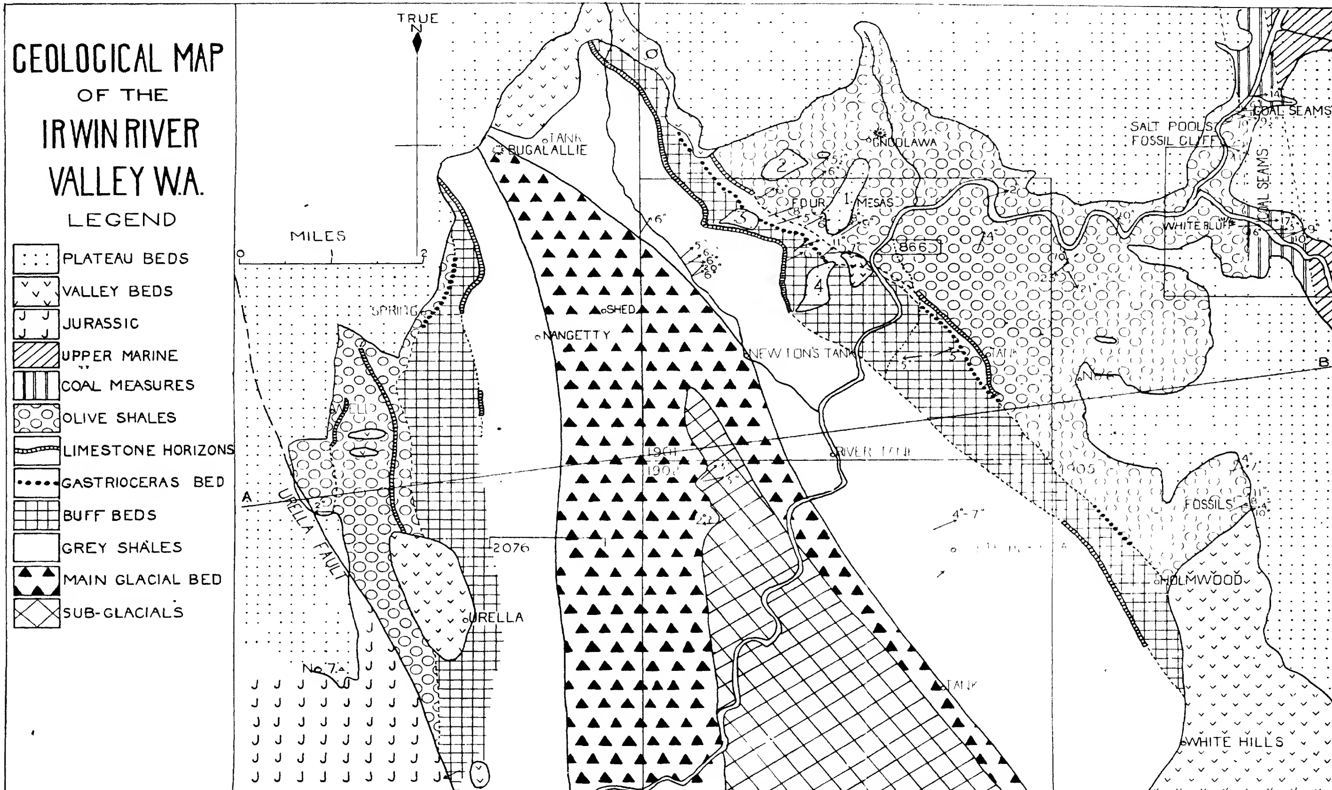
The presence of at least two glacial horizons, one at the base of the system, a second and more extensive one, the equivalent of the Lyons Conglomerate of the Gascoyne-Wooramel District, some 500 feet or more higher in the sequence. A somewhat detailed account of the glaciology is given.

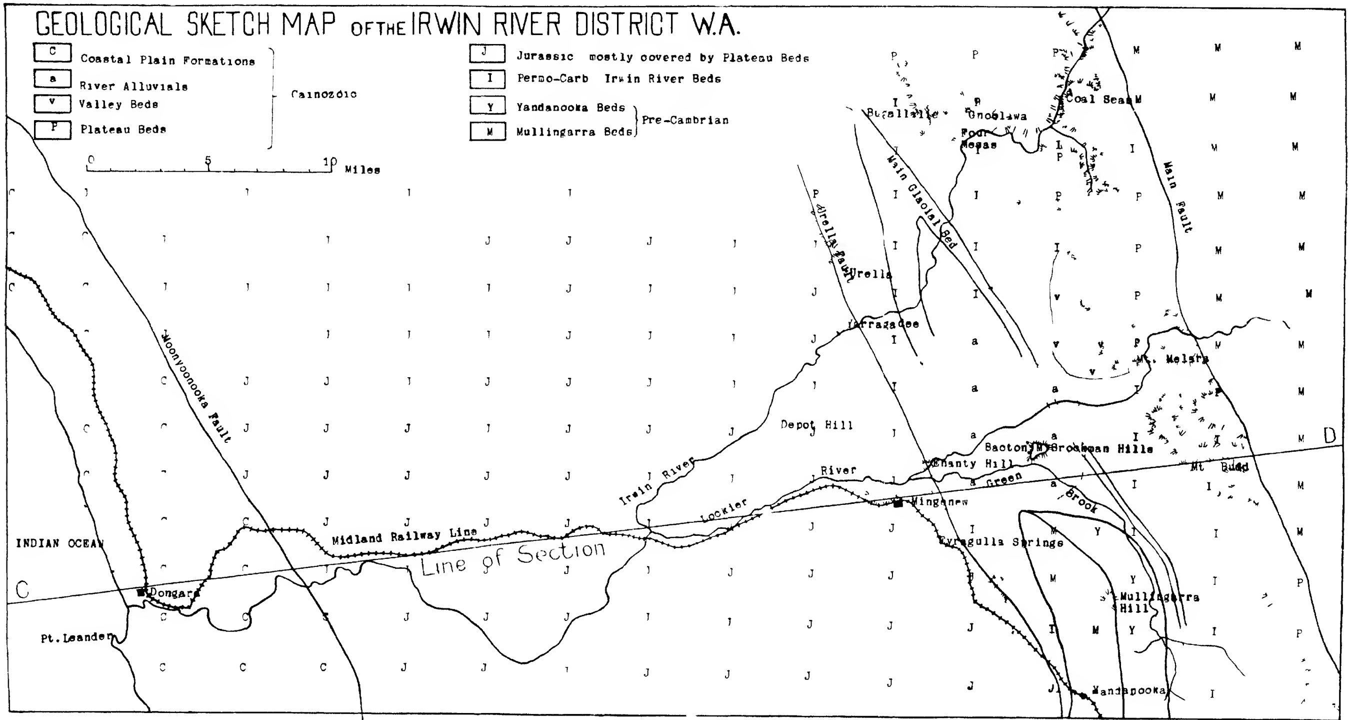
The presence of a gypseous and saliferous horizon; though there do not appear to be deposits of economic value.

The existence of a freshwater series containing coal seams, not of economic value at present. There is evidence of continued glacial action contemporaneous with the coal deposition.

The distribution of beds of Jurassic age is shown to be much more limited than was previously supposed.

Two formations, both probably of Cainozoic age, are recognised. To them we give the names "Plateau Beds" and "Valley Beds," respectively. We believe that the Plateau Beds, in particular, are widespread, and of very great importance in the historic geology of Western Australia.


GEOLOGICAL MAP
OF THE
IRWIN RIVER
VALLEY W.A.
LEGEND
PLATEAU BEDS
VALLEY BEDS
JURASSIC
UPPER MARINE
COAL MEASURES
OLIVE SHALES
LIMESTONE HORIZONS
GASTRIOCERAS BED
BUFF BEDS
GREY SHALES
MAIN GLACIAL BED
SUB-GLACIALS
TRUE N
MILES
0
1
2
TANK
BUGALALLIE
GNOOLAWA
SALT POOLS
FOSSIL CLIFF
COAL SEAMS
FOUR
MESAS
866
WHITE BLUFF
SPRING
SHED
NANGETTY
NEWTON'S TANK
URELLA FAULT
URELLA
2076
No 7
A
B
RIVER TANK
4°-7°
FOSSILS
HOLMWOOD
WHITE HILLS
1901
1905


GEOLOGICAL SKETCH MAP OF THE IRWIN RIVER DISTRICT W.A.
C Coastal Plain Formations
a River Alluvials
v Valley Beds
P Plateau Beds
Cainozoic
J Jurassic mostly covered by Plateau Beds
I Permo-Carb Irwin River Beds
Y Yandanooka Beds
M Mullingarra Beds
Pre-Cambrian
0 5 10 Miles
INDIAN OCEAN
Pt. Leander
Dongara
Moonyoonooka Fault
Midland Railway Line
Line of Section
Irwin River
Lockier
River
Depot Hill
Mingenew
Yarragadee
Urella
Urella Fault
Main Glacial Bed
Coal Seam
Main Fault
Mt. Mulgra
Bootong
Brockman Hills
Enanty Hill
Green Brook
Mt Budd
Yandanooka
Mullingarra Hill
C
D

What we regard as the most important scientific result of our work, is the recognition of *three major step faults throwing from the continent towards the Indian Ocean.*

We wish to express our gratitude to the residents of the Irwin River District for much hospitality and assistance. We would mention especially Messrs. Everard Darlot of Urella, F. Eckermann of Nangetty, Kilmurray of Holmwood, J. O'Halloran of White Hill, A. Black of Bacton, and P. Bridge of Mingenew.

We are much indebted also to Mr. R. Forbes, Senior, for faithful and loyal assistance throughout our investigations, often under conditions much the reverse of pleasant.

The Government Geologist of Western Australia, Mr. A. Gibb Maitland, has always placed his extensive knowledge of Australian geology most freely and unselfishly at our disposal.

In the preparation of the paper, we have received most valuable help from Professor Sir Edgeworth David and members of his staff at the University of Sydney. In this connection we would especially mention Professor Cotton and Mr. W. S. Dun.

DESCRIPTION OF PLATES.

PLATE III.—Detailed Geological map of the Upper Irwin River Valley of Western Australia.

The information embodied in this map is entirely original. Only a few of the land subdivisions are shown, to assist in localising the geological features. The country is occupied in very large areas, and ordinary land survey boundaries are of less value as a basis for geological survey than is usually the case.

The map is oriented to true north, the magnetic variation being 4½ degrees west.

The positions of the homesteads are shown, as also are those of the most important tanks. Water supply is of great im-

portance to any investigator working in this very dry area. Since these tanks are all provided with windmills, they form very useful landmarks for survey purposes in a country almost entirely devoid of conspicuous natural features.

Under Grey Shales are included the Spheroidal Marls and the Grey Limestones. Under Olive Shales are included the Olive Shales proper, and the Fossil Cliff Limestones.

The widths of the limestone beds are exaggerated, and the same symbol is used to designate all the limestone horizons. The beds to which distinctive names have been given will be easily distinguished by reference to the text.

Alluvials of the Irwin River have not been delineated, and the distribution of the Valley Beds is shown only very partially.

PLATE IV.—General Geology of the Irwin River Basin.

The main features of this map have been copied from that of Campbell (Geol. Survey of W.A., Bull. 38, Plate I., Sheet 2). This has been modified where our experience has shown it necessary to do so. The most essential differences are:—

The definite indication of a fault (the Main Fault) between the older rocks on the east, and the Irwin River Beds on the west.

Subdivision of the Pre-Cambrian rocks in the neighbourhood of Yandanooka.

Detailed mapping of the Main Glacial Horizon of the Irwin River Valley.

Mapping of the Urella Fault on the western side of the valley.

Transference of much of Campbell's "Jurassic" to our "Plateau Beds".

Suggestion of the existence of a third fault, the Moonyoonooka Fault, at the boundary between the "Jurassics" and the Coastal Plain.

PLATE V.—Geological Sections across the areas indicated on the maps of Plates III. and IV.

Section A-B is drawn to true scale, and contains full detail.

Section C-D is somewhat diagrammatic. The thicknesses of the formations, other than the Irwin River Beds, are unknown. It is impossible, with the information at hand, to estimate the

throws of the three faults. We consider the evidence for the existence of the Main Fault and the Urella Fault to be conclusive. The existence of the Moonyoonooka Fault is somewhat hypothetical.

APPENDIX.

The body of this paper was completed in 1920, but its publication was unavoidably delayed. Since then, some additional work has been done in the Irwin River District.

Rather than alter the paper as originally written by us, it seems preferable to incorporate these later results as an appendix.

In his Annual Progress Report for 1921 (Perth 1922), the Government Geologist summarises the results of boring for coal carried out by the Public Works Department.

Two bores were sunk in the South Branch of the Irwin River to depths of 674 feet and 723 feet, respectively. The former proved six thin seams of coal, the thickest being only 18 inches. The latter proved seven seams, including one of 12 feet thickness, one of 4 feet 2 inches, and two of 2 feet. In all of them, however, the coal is of very inferior quality, and the results do not justify further prospecting in the same locality.

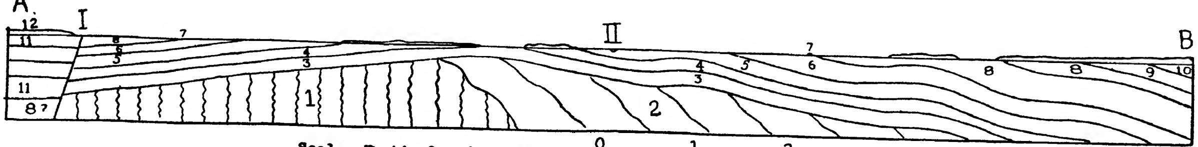
The Government Geologist concludes that:—"The coals of the Irwin River were deposited in shallow water under rapidly changing conditions, tending to result in the formation of very lenticular seams and beds of an erratic character. There is, however, a possibility that in the western portion of the area, somewhat remote from the margin of the basin in which the seams were deposited, any coal beds occurring would be freer from ash and of generally a somewhat higher quality. A bore put down to a sufficient depth somewhere in the vicinity of Urella Station (E. of N. 74) and Yarragadee on the Irwin River on the western flank of the fold into which the Car-

boniferous and Permo-Carboniferous rocks have been thrown, should definitely settle the question for all time."

While we agree entirely with the suggestion that any coals on the western side of the valley are likely to be more pure than those on its eastern side, we are of opinion that the presence of the Urella Fault, which we claim to have discovered, introduces a very serious complication. The effect of this fault must be seriously considered in any proposal for prospecting in the neighbourhood of Urella and Yarragadee.

In the Proceedings of this Society, Volume LVI., pp. 249-252, Mr. W. S. Dun and Sir Edgeworth David have described the specimens of *Gastrioceras Jacksoni* and have pointed out "the great similarity, if not the absolute identity, of *Gastrioceras Jacksoni*, Etheridge, from the Irwin River Coalfield, and *Paralegoceras sundaicum*, Haniel, from the Island of Letti."

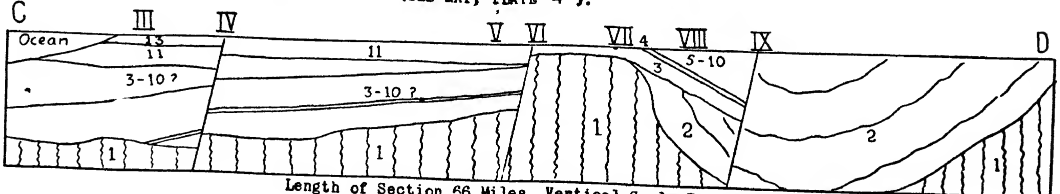
GEOLOGICAL SECTION FROM A. TO B. (SEE MAP, PLATE 3) ACROSS THE IRWIN RIVER VALLEY WESTERN AUSTRALIA
SHOWING SUBDIVISIONS OF THE PERMO-CARBONIFEROUS SYSTEM.



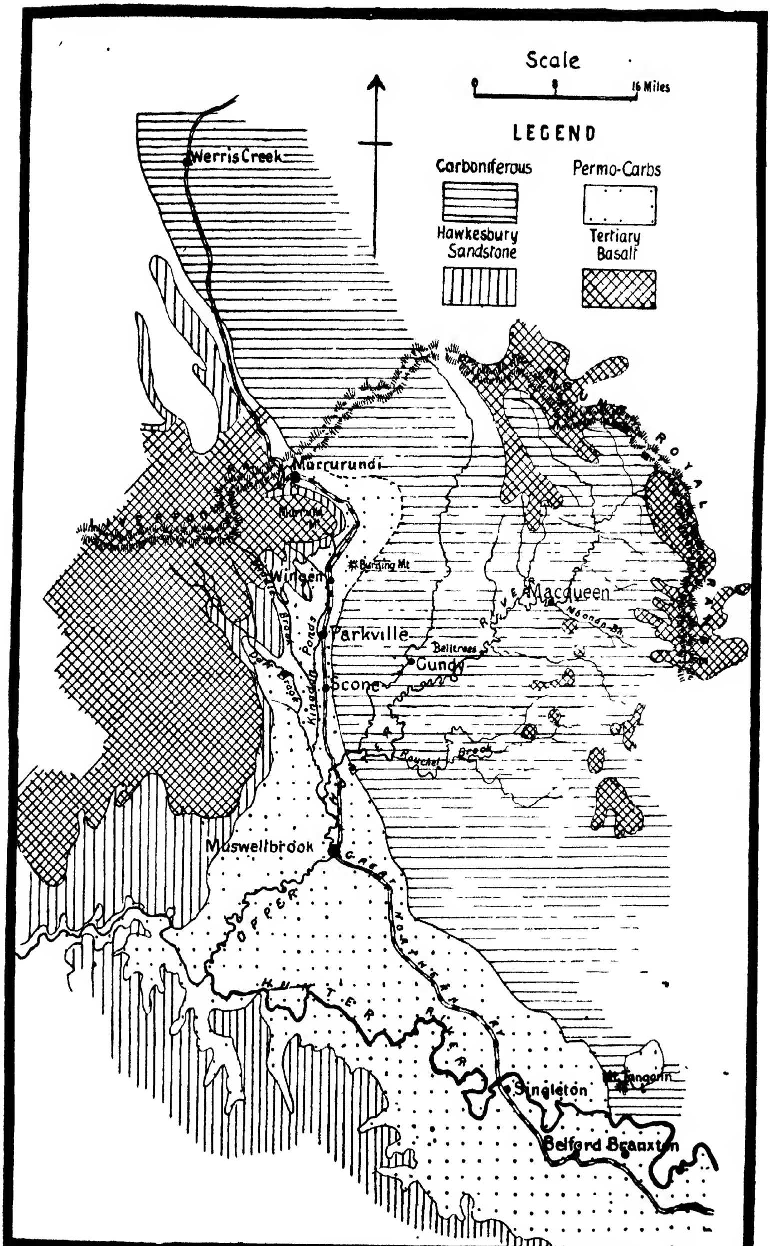
Scale- Vertical and Horizontal 0 1 2 Miles.

1. Mullingarra Gneisses. 2. Yandanooka Beds. 3. Sub-Glacial Beds. 4. Main Glacial Horizon. 5. Grey Shales. 6. Buff Beds. 7. Gastrioceras Bed. 8. Olive Shales. 9. Coal Measures. 10. Upper Marine Beds. 11. Jurassic. 12. Plateau Beds.
I Urella Fault. II. Irwin River.

SOMEWHAT GENERALISED GEOLOGICAL SECTION ACROSS THE IRWIN RIVER VALLEY W.A.
(SEE MAP, PLATE 4).



Length of Section 66 Miles. Vertical Scale Exaggerated.
1.- 12., inclusive, as above; 13. Coastal Plain Beds.
III. Dongara. IV. Moonyoonooka Fault. V. Mingenew. VI. Urella Fault. VII. Green Brook. VIII. Mt. Budd. IX. Main Fault.


Scale
16 Miles
LEGEND
Carboniferous
Permo-Carbs
Hawkesbury Sandstone
Tertiary Basalt
Werris Creek
Murrurundi
Burning Mt
Wingen
Parkville
Scone
Gundy
Belltrees
Macqueen
Muswellbrook
Upper Hunter River
Great Northern Ry
Singleton
Mt Tangorin
Belford
Branxton
Kingdon Ponds
Dart Brook
Pages Ck
Rouchel Brook
Royal

THE ESSENTIAL OIL OF BACKHOUSIA SCIADOPHORA (N.O. MYRTACEÆ) (F.v.M).

By A. R. PENFOLD, F.A.C.I., F.C.S.,
Economic Chemist, Technological Museum, Sydney.

(Read before the Royal Society of New South Wales, July 2, 1924).

The botany of this tree is fully described in Bentham's "Flora Australiensis", Vol. iii., page 270. It is a tall tree growing to a height of 80-90 feet with a diameter of 24 inches, and occurs widely distributed in the North Coast District of New South Wales and Queensland. On account of the valuable oils obtained from the other members of the genus, *Backhousia citriodora* (95% citral), *B. myrtifolia* (75-80% elemicin), and *B. angustifolia* (75% Phenol, $C_{10}H_{14}O_3$), it was deemed advisable to subject the leaves of this tree to examination. Material was kindly furnished in two instances by the District Forester at Casino, New South Wales, and Dr. T. L. Bancroft, of Eidsvold, Queensland. The result of the examination was somewhat disappointing from an economic point of view as only about 0.3% yield of essential oil was obtained, consisting of about 80-85% d-*a*-pinene, the remainder being sesquiterpene and sesquiterpene alcohol. The composition is interesting, however, as the oils of the four species form a remarkable series in regard to diversity of composition.

Essential Oil.

The oils obtained from the two consignments were of a dark brown colour, quite mobile, with a pronounced odour of pinene. Altogether 374 lbs. of leaves and terminal

branchlets were subjected to steam distillation. The principal constituents, so far identified, were found to be d-*a*-pinene (80-85%), sesquiterpene, sesquiterpene alcohol, small quantity of caprylic acid ester and a phenol.

Experimental.

374 lbs. weight of leaves and terminal branchlets yielded, on distillation with steam, crude oils possessing the following chemical and physical constants:—

Date	Locality	Weight of Leaves	Yield of Oil	Specific Gravity $\frac{15}{15}$° C.	Optical Rotation	Refractive Index 20° C	Solubility in 80% alcohol	Ester No. 1½ hours, hot	Ester No. after acetylation	Remarks
22/2/1923	Casino, N.S. Wales	71 lbs.	0·33%	0·8802	+ 34·2°	1·4717	insoluble 10 vols.	14·64	54·24	leaves very dry
2/10/1923	Eidsvold, Queensland	303 lbs.	0·28%	0·8799	+ 33·7°	1·4704	do.	27·52	44·45	moisture, 10·4%

On distillation at 10-20 mm. both samples yielded about 80%, boiling at 55-70° C. (20 mm.), 4% at 70-130° C. (10 mm.), and 15% at 130-135° C. (10 mm.).

Determination of d-a-pinene. Repeated fractional distillation of the portions boiling below 70° C. at 20 mm. resulted as follows:—

Specimen	Boiling Point	Sp. Gr. $\frac{15}{15}$° C.	Opt. Rot.	Ref. Index 20° C.	Volume of Crude Oil
Casino sample	154–155° C (760 mm.)	0·8633	+ 40·25°	1·4655	44%
	155½–157°C	0·8635	+ 39·25°	1·4656	15%
Eidsvold, Queensland	154–155° C. (750 mm.)	0·8633	+ 40·45°	1·4656	33%
	155½–158°C	0·8634	+ 40·4°	1·4656	30%

The fractions distilling at 154-155° C. were used for the following experiments:—

(a) 32 c.c. were shaken with 67 grams powdered potassium permanganate, 800 c.c. water and 450 grams ice until the reaction was completed. On subsequent treatment (See Vol. LVII., 1923, page 242) about 15 grams pinonic acid were obtained, distilling at 174-176° C. at 5 mm., which readily solidified on standing overnight. The crystals were separated and purified from petroleum ether when they melted at 68-69° C. The semicarbazome prepared therefrom melted at 207° C. 0.6853 gram of the acid in 10 c.c. chloroform gave $[a]_d$ 23° C. + 89°.

(b) The hydrochloride prepared in the usual way on crystallisation from ethyl alcohol melted at 126-127° C. 0.3534 gram in 10 c.c. ethyl alcohol gave $[a]_d$ 24° C. + 39.6°.

Determination of sesquiterpene and sesquiterpene alcohol. —The high boiling fractions of both consignments were united and examined as one, although the optical rotation of the Casino specimen was — 1.25°, whilst that of the Eidsvold sample was + 16°. The mixture was found to have an ester No. of 38.84 after removal of about 1% phenol. It was accordingly saponified, and the resultant oil on separation was repeatedly distilled over sodium at 10 mm. until finally about 12 c.c. of a pale lemon-tinted oil of boiling point 130-135° C. at 10 mm. was obtained possessing the following characters:—

Specific gravity, 15/15° C., 0.9322, optical rotation + 9°, and refractive index, 20° C., 1.4960. It gave the usual colour reactions with bromine in glacial acetic acid solution and sulphuric acid in acetic anhydride solution characteristic of the sesquiterpenes of the *Myrtaceæ*, and although it closely resembles aromadendrene in forming

a liquid hydrochloride as well, the small quantity available prevented its rigorous purification.

The higher boiling portion behaved as a sesquiterpene alcohol.

Combined Acid.—The alkaline liquor after saponification of the small quantity of ester present was acidulated and subjected to steam distillation, when a small quantity of oily acid, of most unpleasant odour, passed over. It appeared to be identical with caprylic acid judging from the behaviour of the silver salt on ignition:—

0.035 gram silver salt gave 0.0148 gram silver—42.3%

$C_8H_{16}O_2$—43%

Phenolic body.—The crude oil on extraction with 5% sodium hydroxide solution gave 1.3% of a liquid phenol of refractive index, 1.5034 at 20° C., which gave a dark brown colouration with ferric chloride in alcoholic solution. No crystalline derivatives could be obtained.

I desire to express my thanks to Dr. T. L. Bancroft, Eidsvold, Queensland, for his kindness in furnishing an excellent supply of leaves free of cost, and to Mr. F. R. Morrison, A.T.C., A.A.C.I., Assistant Economic Chemist, for much assistance in the chemical examination of the oil.

THE GERMICIDAL VALUES OF THE PURE CONSTITUENTS OF AUSTRALIAN ESSENTIAL OILS, TOGETHER WITH THOSE FOR SOME ESSENTIAL OIL ISOLATES AND SYNTHETICS. PART II.

By A. R. Penfold, F.A.C.I., F.C.S.,
Economic Chemist, Technological Museum, Sydney,
and
R. Grant, F.C.S.,
Assistant Microbiologist, Department of Public Health, Sydney.

(*Read before the Royal Society of New South Wales, July* 2, 1924.)

In continuation of the investigations published in the Society's Journal for 1923 (Vol. LVII., pages 211-215), the following table contains a further series of essential oil constituents, isolates and synthetics, the Rideal-Walker co-efficients of which have been determined. Although about 100 of these bodies have been examined for germicidal properties, a considerable amount of investigation is still necessary before sufficient evidence is available for generalisation. The series under review contains many esters, the examination of which was conducted with a view to confirming a footnote in the Part I. paper referred to (page 214), which stated, "It may be mentioned that so far as our experience goes it appears that the co-efficient of esters depends upon the acid radical, and is independent of the alcohol, irrespective of whether the latter possesses a high or low value." This has been found to be only partly true, the table given in this paper containing a number of exceptions. The co-efficient for anthranilic acid is very remarkable, as, contrary to expectation, it appears to be more highly dispersed in alcohol than in

water, the increase in the germicidal value being equal to 500 per cent.

Concerning the esters, it is necessary to remark that Messrs. Boake, Roberts, and Co. Ltd., Stratford, E.15, very kindly donated to the Technological Museum a series of valerianic acid esters for exhibition purposes and to assist the Economic Chemist in the examination of Australian essential oil yielding plants, a number of which have been found to contain valerianic acid esters in quantity. These oils have, however, been found to present considerable difficulty under examination. In view of the excellent range of specimens so kindly furnished, we availed ourselves of the opportunity thus presented of determining the Rideal-Walker co-efficients of a range of esters of one particular acid.

We have included in the table the results of an examination of synthetic menthols as compared with the natural, which shows that they are equivalent in germicidal properties, the co-efficient in every instance being 20.

Another interesting result is that obtained with camphor. In the paper referred to, page 213, the co-efficient of camphor was given as 6, which result we have confirmed. The suspension used of this ketone in rosin soap solution was somewhat turbid, and it was found that on addition of sufficient absolute ethyl alcohol to produce a clear solution and re-testing, the co-efficient was found to be 11, an increase of 83 per cent. This offers confirmation in a most striking manner of our statement that the germicidal value of a disinfectant depends upon the degree of dispersion. This increase in the dispersion of camphor is very noticeable to the sense of smell. Although advantage has been taken of this increased dispersion by medical men, from practical experience of its value in the treatment of colds, etc., we think that the true cause has not previously been published.

The results we have so far obtained tempt us to make the following comments. Text books on Bacteriology and works on Public Health emphasise the value of sunlight, or, rather, the direct rays of the sun, as being strongly germicidal (the ultra-violet portion) in their action, and pathogenic bacteria exposed to the rays for varying periods either lose their toxic or virulent properties or are completely destroyed. The atmosphere contains a considerable number of micro-organisms in suspension—pathogenic and non-pathogenic—the number varying with the atmospheric conditions, the altitude and the place. In connection with the age mortality of the different professions and trades, it has been pointed out that gardeners head the list for longevity, and doubtless this is due to the fact that the atmosphere in which they work is comparatively pure. Our examinations of the different perfume constitutents, alcohols, aldehydes, esters, phenols, etc., have shown that most of them possess strongly germicidal properties. In nature the different esters, alcohols, etc are blended in the correct, or rather the most suitable proportions to give the greatest dispersion. No bacteriological examinations of the air in the vicinity of flower gardens or in the bush have been made to our knowledge, but it is quite well known that minute quantities of the odoriferous constituents of plants are liberated into the air. The use of perfumes by women also probably accounts for the fact that they suffer less than men from a number of ailments that are due to microbic infection.

Experimental.

The Rideal-Walker tests were carried out as described in previous papers, (this Journal, Vol. LVI., 1922, 219-226), standard suspensions of 1 per cent. of the bodies referred to being prepared in 7½ per cent. rosin soap

solution, with the exception of coumarin, vanillin, valerianic acid, and anthranilic acid. The two first named were best prepared in acetone solution, the co-efficient of this solvent being 0.028. Valerianic acid was tested in aqueous solution, whilst the last named was prepared in both aqueous and ethyl alcoholic solution.

Table.

Constituent	Nature.	Source.	Constants. (Sp. gr. at 15/15° C) (R.I.=Refractive Index 20° C)	Coefficient
Linalool	alcohol	Geijera sp. (at present unpublished)	B.Pt., 10 mm. 85 - 87° C. Sp. gr. 0·8702 Opt. rot. - 12° R.I. 1·4636	13
Linalyl acetate	ester	Museum stock	B.Pt., 10 mm. 98 – 100° C. Sp gr. 0·9072 Opt. Rot. – 4·8° R.I. 1·4516	5·25
Coumarin	lactone	do.	M.Pt. 69 – 70° C.	4
Vanillin	lactone	do.	M.Pt. 83 – 84° C.	3·5
Isomenthone	ketone	electrolytic reduction of piperitone	B.Pt., 760 mm. 207 – 209° C. Sp. gr. 0·904 Opt. rot +5·2° R.I. 1·4560	14
Methyl eugenol ether	phenol ether	Museum stock	B Pt., 10 mm 128 – 130° C. Sp. gr. 1·0428 Opt. rot. ±0 R.I. 1·5333	13·5
Darwinol	alcohol	*Darwinia grandiflora*	B Pt., 10 mm. 108 – 111° C. Sp. gr. 0·9559 Opt. rot. +88·6° R.I. 1·4918	13
Darwinol acetate (82%)	ester	do.	B.Pt., 10 mm. 108 - 113° C. Sp. gr. 0·9672 Opt. rot. +33° R.I. 1·4760	3

Constituent	Nature	Source	Constants (Sp. gr. at 15/15° C.) (R.I.=Refractive Index at 20° C.)	Coefficient.
Bornyl acetate	ester	Museum stock	B.Pt., 10 mm. 98°C. Sp. gr. 0·9872 Opt. rot. +39° R.I. 1·4654	6
Amyl salicylate	do.	do.	B.Pt., 10 mm. 143 – 145° C. Sp. gr. 1·0526 Opt. rot. +1·1° R.I. 1·5065	4
Benzyl alcohol	alcohol	do.	B. Pt., 10 mm. 94 – 95° C. Sp. gr. 1·0502 Opt. rot. ±0 R.I. 1·5389	5·25
Benzyl acetate	ester	do.	B. Pt., 10 mm. 95 – 96° C. Sp. gr. 1·0601 Opt. rot. ±0 R.I. 1·5038	2
Benzaldehyde	aldehyde	do.	B. Pt., 10 mm. 66 – 67° C. Sp. gr. 1·0509 Opt. rot. ±0 R.I. 1·5432	9
Anthranilic acid	acid	do.	M. Pt. 144 – 145° C.	2* 12†
Methyl anthranilate	ester	do.	B. Pt., 10 mm. 129 – 130° C. M. Pt. 24° C. Sp. gr. 1·172 Opt. rot. – 0·25° R.I 1·5816	6·5
Anethole	phenol ether	do.	M. Pt. 22 – 23°C. B. Pt., 10 mm. 108 – 110° C. Sp. gr. 0·9958 Opt. rot. ±0 R.I. 1·5600	11
Anisaldehyde	aldehyde	do.	B. Pt., 10 mm. 120 – 121° C. Sp. gr. 1·1279 Opt. rot. ±0 R.I. 1·5720	7

* Aqueous solution. † Ethyl alcohol solution.

Constituent	Nature.	Source.	Constants. (Sp. gr at 15/15° C.) (R.I.=Refractive Index at 20° C.)	Coefficient.
Cinnamic aldehyde	aldehyde	Museum stock	B. Pt., 10 mm. 121·5 – 122·5° C. Sp. gr. 1·0541 Op. rot. ±0 R. I. 1·6182	17
Menthol (synthetic)	alcohol	reduction of piperitone vice isomenthone	M. Pt 23 – 24° C. B. Pt., 774 mm. 212 – 213° C. Sp. gr. 0·9068 Opt. rot. – 3·6° R. I. 1·4634	20
Menthol (synthetic)	do.	do.	M. Pt. 34° C. B. Pt, 774 mm. 212 – 213° C. Sp. rot. ±0	20
Menthol (natural)	do.	Museum stock	M. Pt. 43 – 44° C. Sp. rot. 20° C. – 50°	20
Valerianic acid	acid	Boake, Roberts	B. Pt., 10 mm. 75 – 76° C. Sp. gr. 0·9362 Opt. rot. +0·7° R. I. 1·4038	2
Ethyl valerianate	ester	do.	B. Pt., 10 mm. 43°C. Sp. gr. 0·8714 Opt. rot. + 0·5° R. I. 1·3959	4·5
Butyl valerianate	do.	do.	B. Pt., 10 mm. 66 – 67° C. Sp. gr. 0·8659 Opt. rot. + 0 5° R. I. 1·4089	10
Isobutyl valerianate	do.	do.	B. Pt., 10 mm. 60 – 61° C. Sp. gr. 0 8638 Opt. rot. + 0·48 R. I. 1·4058	8·5
Propyl valerianate	ester	do.	B. Pt., 10 mm. 53°C. Sp. gr. 0·8659 Opt. rot +0·52° R. I. 1·4043	8

Constituent	Nature	Source.	Constants. (Sp. gr. at 15/15° C.) (R.I = Refractive Index at 20° C.)	Coefficient
Amyl valerianate	ester	Boake, Roberts	B. Pt., 10 mm. 76 5° C. Sp. gr. 0 8627 Opt. rot. + 1·25° R. I. 1·4127	5
Menthyl valerianate	do.	do.	B. Pt., 10 mm. 131 - 132·5° C Sp. gr. 0·9087 Opt. rot. - 51·5° R I. 1·4475	3
Benzyl valerianate	do.	do	B. Pt., 10 mm. 117 - 119° C. Sp. gr. 0·9957 Opt rot. + 0.2° R. I 1·4878	6
Phenyl ethyl valerianate	do.	do	B. Pt., 10 mm. 132 - 134° C. Sp. gr. 0 9832 Opt. rot. + 0·3° R. I. 1·4854	4
Geranyl valerianate	do.	do.	B. Pt., 10 mm. 136 - 140° C. Sp. gr. 0·8907 Opt. rot. + 3·7° R. I. 1 4570	2
Rhodinyl valerianate	do.	do.	Sp. gr. 0 9806 Opt. rot. + 0·45° R. I. 1·4587	1
Citronellyl valerianate	do.	do.	B. Pt., 10 mm 139·5 - 140·5° C. Sp. gr. 1·8875 Opt. rot + 1·6° R I 1·4540	2

We have again to express our thanks to Mr. G. Hooper, F.T.C., Curator of the Technological Museum, for enabling our co-operation, and to Dr. E. W. Ferguson, Principal Microbiologist, Department of Public Health, Sydney, for kind permission to carry out the bacteriological work, and to Mr. F. R. Morrison, A.T.C., A.A.C.I., Assistant Economic Chemist, for much assistance in the chemical part of the paper.

NOTES ON EUCALYPTUS PIPERITA AND ITS ESSENTIAL OILS, WITH SPECIAL REFERENCE TO THEIR PIPERITONE CONTENT. PART I.

By A. R. PENFOLD, F.A.C.I., F.C.S.,
Economic Chemist,
and
F. R. MORRISON, A.T.C., A.A.C.I.
Assistant Economic Chemist, Technological Museum, Sydney.

(*Read before the Royal Society of New South Wales, July* 2, 1924.)

In a "Research on the Eucalypts" (2nd Edition) by Messrs. Baker and Smith, pages 274-275, is described the essential oil of *E. piperita,* commonly known as the "Sydney Peppermint." These investigators detail the results of examinations of material collected at Gosford in April, 1897, and Wingello in January, 1901, the yield of oil from the first named being 0.8 per cent. (no yield is stated for the Wingello lot), which oils on distillation gave 85-86 per cent. distilling below 200° C. Although there is, so far as we know, no record of the quantity of piperitone present in this species it could not have been more than 5-10 per cent., and this has usually been assumed to be the case. Many enquiries have been made by persons clearing their property of this species for information regarding the oil, and we have advised them according to the foregoing results. Field observations made by us during the past few years, however, have led us to suspect that the trees of this species growing around Port Jackson contained much more than the published yield of oil (0.8 per cent.), and from the odour of the crushed leaves

that piperitone was present in considerable quantity. Consequently, we decided to reinvestigate the matter at the first opportunity, and material was collected from such places as Longueville, Kuringai, Como, etc., with the result that our field observations were confirmed, the leaves and terminal branchlets, cut as for commercial distillation, collected about the same period of the year, March-April, and weighed when fresh, yielded from 2 to 2.5 per cent. of oil, containing 40-50 per cent. piperitone. The oils thus obtained closely resembled those from *E. dives,* so much so that it is doubtful if an unlabelled specimen of each could be differentiated. These results are especially interesting, as they confirm in a very striking manner the observation of Surgeon-General White made in the "Journal of a Voyage to New South Wales," published in London, in 1790, that the name of "Peppermint Tree" had been given to this plant on account of the very great resemblance between its essential oil, and that of the English peppermint, "*Mentha piperita.*" We must confess that we have always felt doubtful that Mr. White could have made such a reference if the oil had resembled that described by Messrs. Baker and Smith, where the piperitone content did not exceed 10 per cent. These authors state, in the work mentioned, page 274, under Remarks: "In this research particular interest pertains to this species as it was from trees of the 'Sydney Peppermint,' growing where Sydney now stands, that the first Eucalyptus oil was obtained. It was distilled by Dr. White, Surgeon to the First Fleet in 1788," and it seems remarkable that they did not at the time of their investigation examine the oils from trees growing in or around Sydney as well as those from 50-100 miles away. We believe that the composition of the oil described under "Experimental" most closely resembles that first distilled in 1788.

In view of this disparity between their results and our own we have carried out a considerable number of observations and experiments on oils obtained from this species growing in various localities and altitudes, and have come to the conclusion that apart from slight variations likely to be due to the influence of ecological conditions, that there are two very distinct forms of this tree, one growing close around Sydney, say, the Port Jackson district, yielding 2-2½ per cent. of oil containing 40-50 per cent. piperitone, and the other yielding only 0.6 to 0.8 per cent. of oil low in piperitone, but high in phellandrene and eudesmol, and containing up to 20 per cent. cineol, found principally in the more mountainous districts. This latter is tentatively termed the mountain form or variety "A," to distinguish it from the typical form.

The type, *E. piperita,* and its varied forms are being carefully studied, and the final result of our observations will be dealt with in a later publication. Meanwhile, we prefer merely to direct attention to the striking difference in the composition of the oils of two very distinct forms, and to the interesting nature of that obtained from trees growing at Port Jackson, the chemical and physical constants of which are totally different to anything that has previously been published concerning the oil of this species.

In the table particulars are given only of the oils from the Port Jackson trees, those from other localities being left for a later communication.

Experimental.

Leaves and terminal branchlets collected as described, and subjected to steam distillation, yielded the following crude oils:—

Date.	Locality	Weight of Leaves	Yield of Oil	Specific Gravity $\frac{15}{15}$°C
18/3/1924	Longueville	161 lbs.	2·01%	0·8924
29/3/1924	Kuringai	104 lbs.	2·42%	0·9016
8/4/1924	Como	28 lbs.	2·02%	0·8977

Optical Rotation	Refractive Index 20° C.	Solubility in 70% alcohol	Piperitone content
– 64°·60	1·4805	1 in 9 vols.	42%
– 52°·00	1·4821	1 in 5·6 „	42%
– 62°·75	1·4805	1 in 5·3 „	48%

These oils on distillation yielded on an average 40 per cent. distilling at 60-75° C. at 10 mm., 18 per cent., at 75-100° C., and 42 per cent. at 100-110° C.

Separation of phellandrene and piperitone.—The portion distilling at 60-75° C. at 10 m.m. on fractionation readily yielded phellandrene of B.Pt. 59-61° C. at 10 mm., having a specific gravity at 15/15° C. of 0.8467, optical rotation—93°, and refractive index, 20° C., 1.4729. The last-named portion (B.Pt. 100-110° C. at 10 mm.) was found to consist principally of laevo-rotatory piperitone having an optical rotation of – 57°. On purification through the bisulphite compound, it possessed the following characters:—B.Pt. at 10 mm, 107-108° C., Sp.Gr., 15/15° C., 0.9386, optical rotation – 10°, and refractive index, 20° C., 1.4836. Cineol was not detected in the terpene fraction.

NOTES ON THE PHYSIOGRAPHY AND GEOLOGY OF THE UPPER HUNTER RIVER.

By W. R. BROWNE, D.Sc.

Assistant-Professor of Geology, University of Sydney.

(With Plate VI.)

(*Read before the Royal Society of New South Wales, August* 6, 1924.)

General.

A glance at the geological map of New South Wales shows that the Great Northern railway line between Belford and Quirindi follows an approximately linear course, and that it keeps fairly close all the way to the western boundary of the Carboniferous area. There is something more than mere coincidence in these facts, and the significance of them was impressed on the author in the course of a couple of trips in the early part of the present year, during which it was possible to view the country, cursorily for the most part it is true, as far north as Wingen.

The traveller who journeys northward by day along the Great Northern Railway or the Great Northern Road from Branxton, can scarcely fail to be struck by some of the physiographic features of the country on either side of him. Road and railway alike run for the most part through a wide stretch of level or gently undulating country, which is bounded in the distance by lines of hills or cliffs. From Branxton, on looking to the south and south-west, one may see the Hawkesbury sandstone cliffs of the Broken Back Range, bounding the broad Hunter valley in that direction. To the north, some six or eight miles away, the same valley is bounded by the

group of hills, composed of hard Carboniferous lavas and sediments, clustering around Tangorin; immediately to the west these are succeeded by a group of lower Carboniferous hills which rise abruptly from the level country.

From the high ground on the road north of Singleton the Carboniferous hills, Mirannie and others to the north of it, are seen to the north-east, perhaps eight or ten miles away, these being the northward continuation of those seen from Branxton; on the west the Broken Back Range is still to be seen, about 10 miles away.

From Singleton to Muswellbrook both road and railway follow along the base of a triangle, the other two sides of which are formed by the Hunter and its principal tributary, the Upper Hunter, whose junction forms an acute angle directed to the west. As Muswellbrook is approached the eastern line of hills comes closer and on the flat straight stretch of road and line north of Muswellbrook along the valley of Kingdon Ponds cuttings are actually made through the base of the Carboniferous hills near Wingen. The western wall of cliffs is not so noticeable from the road, partly because the route is so far to the east of it between Singleton and Muswellbrook, and partly because the valleys in which the road often runs are countersunk below the level of an older valley floor, so that the view to the west is limited. It is only when one climbs out of these newer valleys on to the floor of the older that the rampart of Hawkesbury sandstone can be seen.

North from Muswellbrook the western barrier closes in towards the east. The first view of it as seen from the road between Parkville and Wingen is very impressive: erosion by tributaries of Kingdon Ponds, such as Middle Brook and Stony Creek, has almost isolated a great elongated mass of the sandstone, which, with its characteristic

vertical cliffs, stands out boldly from the less elevated country. Beyond Wingen the sandstone sweeps round to the east, apparently closing the valley to the north, and as it appears to have a strong component of dip to the north and east its upper surface decreases in elevation when traced in those directions. But on its top there are piled the great thick masses of Tertiary basalt forming Murulla Mountain, a spur of the Liverpool Range, descending fairly sharply towards the east to the gap through which the railway line passes.

The physiography of the Hunter River basin has been to a large extent determined by the lithological characters of the geological formations composing it, a circumstance first pointed out by Professor Griffith Taylor*, although it seems that some of his conclusions are open to question. For example although the Goulburn River is the structural continuation westwards of the Hunter it is, I understand, quite a small stream in comparison with the Upper Hunter, which is the longest of the tributaries and carries most water to the parent stream. It would appear, indeed, that the Upper Hunter is an abnormally developed subsequent tributary, standing to the Lower Hunter in the same relationship as the Upper does to the Lower Shoalhaven, or the Warragamba-Nepean to the Lower Hawkesbury, and that the Goulburn is to the Hunter what the Colo is to the Hawkesbury—a consequent tributary of little importance. It seems hard to believe that the Goulburn, with its relatively immature valley, could ever have been the main channel of a western-flowing Hunter, as Professor Griffith Taylor conceives it to have been.

Further, the lowering of the divide at the head of the Goulburn to 2000 feet above sea-level is not entirely due

*Proc. Linn. Soc. N.S.W., Vol. XXXI, 1906, p. 517; Commonwealth Weather Bureau Bull. No. 8, 1911, p. 13.

to erosion in the soft coal-measures, since the outcropping rock is in part Hawkesbury sandstone. Mr. E. C. Andrews interprets the low divide there as mainly a tectonic feature, due to warping or faulting.*

However, the great width of the Hunter valley is without doubt to be ascribed to the fact of its having been cut through the comparatively soft Permo-Carboniferous sediments, and, as Mr. Andrews† has pointed out, there is evidence that a very wide valley, excavated during a period of prolonged stability in late Tertiary times, has been cut into as the result of one or more uplifts, which have rejuvenated the streams and produced valley-in-valley structure. The walls of the oldest valley are those, composed of Hawkesbury sandstone and Carboniferous rocks respectively, which are described above, and the river and its tributaries, within the strip of country thus delimited, flow entirely over Permo-Carboniferous rocks, the present channels being sunk about 200 feet below the ancient valley floor.

But there is another and very important circumstance which has affected the drainage, working in conjunction with the lithological factor. The country has been subjected to very heavy faulting, which has had the effect of bringing the Permo-Carboniferous rocks, as high stratigraphically as the Newcastle Coal-measures, against those of the Carboniferous. One of these, the Lachnagar fault of Professor David, has been a very material factor in directing the course of the Lower Hunter between Stanhope and Eelah, an area which is at present being geologically examined by the author. Another, the Elderslee fault, has been traced and mapped by Professor David in a more or less meridional direction from Pokolbin

*B.A.A.S., 1914, N.S.W. Handbook, p. 529.
†loc. cit., p. 523.

across the Hunter valley to Brooks' Mount, north of Branxton. It is at the junction of these two faults that the high country about Mt. Tangorin, alluded to above, occurs, the Carboniferous rocks having resisted erosion very much more than the softer freshwater and marine Permo-Carboniferous sediments. Dr. A. B. Walkom,* in the map accompanying his paper on the Cranky Corner Coal-basin, shows the Elderslee fault to be cut off some miles north of Brooks' Mount by a heavy cross-fault which he has named the Webber's Creek fault. A consideration of the map, however, makes it seem more probable that the Elderslee fault is really offset to the west, and continues north parallel to its original direction, still serving to bring Permo-Carboniferous rocks on the west against Carboniferous rocks on the east.

Physiography of the Country between Muswellbrook and Wingen.

The author has had an opportunity of examining a submeridional fault at intervals from near Muswellbrook to Wingen, and has been struck with the resemblance of the general results of its occurrence with those of the Elderslee fault north of Branxton. At Lupton Park coal-mine, a few miles east of Muswellbrook, the workings are overlooked by Bell's Mountain, of Carboniferous rocks, rising to a height of 2240 feet above sea-level. A little north of Aberdeen the scarp is breached by the mature valley of the Upper Hunter. At Scone erosion has cut back eastwards across the fault-plane for a distance of about half-a-mile, for some reason which is not apparent. Thence the fault trends northward, passing about a mile to the east of Parkville, eventually touching the railway line near Wingen township, thereafter swinging to the north-east,

*Proc. Linn. Soc. N.S.W., Vol. XXXVIII, 1913, p. 146.

passing probably about half-a-mile to the east of the Burning Mountain. Farther than this the fault, which may be termed the Wingen fault, has not been traced by the author. It is this fault that brings the hard Carboniferous rocks to the east into juxtaposition with the soft Permo-Carboniferous sediments in which the valley has been cut. Minor parallel faulting has been observed in the Permo-Carboniferous rocks, which has apparently no great physiographic significance.

The Creek known as Kingdon Ponds is formed by a number of tributaries taking their rise mainly in the Liverpool Range. It flows in a broad meridional valley, widely alluviated, and sharply bounded on the east by the Carboniferous hills. At Scone the Kingdon Ponds is joined by a sub-parallel tributary, Middle Brook, on the right bank, and the combined stream flows south, joining with the Dart Brook and emptying, about four miles south of Aberdeen, into the Upper Hunter. This river has flowed south-west from Macqueen (Moonan Flat) crossing the fault-plane just north of Aberdeen, and after receiving Kingdon Ponds it flows south to Muswellbrook before turning south-west to join the Lower Hunter.

On climbing up the right bank of Kingdon Ponds at Wingen, at an altitude of about 200 feet above the creek level one emerges on to gently undulating country extending to the west for about three miles, to the base of the Hawkesbury sandstone cliffs. This country represents the level of erosion of the ancestor of Kingdon Ponds, a very mature valley into which the present creek valley has been entrenched by moderate uplift, and which has since been partially dissected.

This is perhaps the best place from which to observe the valley-in-valley structure, since further south both the

old and the new valleys widen, so that the relationship is not so easily comprehended.

There can be no doubt that the valley of Kingdon Ponds and its extension as far south as Muswellbrook have been determined by the existence of the Wingen fault. As already stated the eastern wall of the valley is mainly of Carboniferous rocks, but here and there, as at the Burning Mountain, and to the south of it almost to Wingen itself, there are ridges and foothills of hard Permo-Carboniferous conglomerate and sandstone, showing that the fault-plane has not yet been reached by the headwaters of Kingdon Ponds.

Apart from the directive effect of the fault on the stream's course through the juxtaposition of hard and soft strata, it has produced two other results:—

(1) By giving the Carboniferous rocks a strong local dip to the west it has minimised any possibility of erosion towards the east, which might have been to some extent facilitated by an easterly dip.

(2) By giving to the Permo-Carboniferous rocks near the fault-plane a high dip to the west, which flattens out away from the fault, it has (a) imposed on the creek a more pronounced meridional trend, due to following the constant strike of the harder and softer strata rather than the somewhat irregular trend of the fault, and (b) has caused the creek bed to migrate towards the west, that is, parallel to the dip.

As a result of this tendency of Kingdon Ponds to migrate westwards we find its present valley characterised by asymmetrical cross-sections, the right bank being relatively steep and rocky while the left bank is gently sloping and much alluviated. These remarks apply to the creek north of Scone, for at Scone itself, where Middle Brook

enters, the old valley floor has been widely eroded and there is a deeply alluviated flood-plain.

Geology of the Upper Hunter.

In the course of a motor-car trip which, through the kindness of Mr. W. J. Enright, B.A., and other Maitland citizens, the author was privileged to make, it was possible to see something of the stratigraphy and physiography of the country traversed by the road through Gundy and Belltrees to Macqueen (Moonan Flat) and thence towards the Barrington Tops plateau. This road follows for a good part of its course the valley of the Upper Hunter, and some very fine natural sections of the geological formations are exposed where the river in its windings has cut into the walls of its valley.

As far as could be made out, the Kuttung rocks, comprising acid lavas, tuffs, conglomerate and varves, have given place to Burindi tuffs and conglomerates about seven miles from Scone towards Gundy. About three miles beyond Gundy there outcrop what look very like Devonian beds, which continue for quite a distance along the road. About five or six miles from Moonan Flat a good section of these beds is exposed in a road-cutting, where the beds are locally almost horizontal, and faulting is well shown. The rocks are dark-coloured and cherty, with light-coloured (?decomposed tuff) laminae containing obscure plant-remains. The dark layers resemble the Tamworth cherts and contain casts of radiolaria.

From these characteristics the rocks are tentatively referred to the Devonian.

At Moonan Flat itself there is considerable development of acid tuff among the shales, and this feature is very marked where the road to Barrington Tops leaves the comparatively level ground and ascends the steep spurs

past Dry Creek. It is not clear whether these rocks are Devonian or Carboniferous, but probably they are of Burindi age: at all events Burindi fossils have been found by Mr. M. Morrison, of the Geological Survey, at the Moonan Brook settlement, about eight miles up the Brook from Moonan Flat. The relationships of the Devonian and Carboniferous rocks are not clear, but certainly, judging from the dip-directions, there has been much folding.

At Baker's selection, about 14 miles from Moonan Flat towards the Barrington Tops, on the right of the road, there is a little flat-topped hill, about 150 yards across, of Tertiary nepheline-bearing dolerite, possibly representing a plug. About 2½ miles further on, near Wells' Swamp, the prevailing cherts, shales and tuffs are capped by Tertiary basalt, over which the road runs as far as Wharton's Mill and beyond that spot, which is approximately 3900 feet above sea level, the basalt having associated with it nepheline dolerite, possibly in the form of intrusive sheets. The thickness of lava represented in the distance traversed is of the order of 750 feet, and the basalt is said to continue to the top of the plateau, so that the total thickness may be between 1500 and 2000 feet. The basalt so far as observed is quite continuous, and outliers of it occur as cappings to some of the conical hills rising from the Upper Hunter valley nearer Moonan Flat. There is no sign of faulting such as Mr. C. A. Sussmilch has described in his paper on the Gloucester District,* and the basaltic outliers suggest that the thick flow or flows of Tertiary basalt formerly extended across to the west, probably as far as Wingen and Scone and Muswellbrook, while the basalt cappings to the Hawkesbury sandstone of the Goulburn River country give some indication of the former westerly extension of these great lava-flows.

*Jour. Roy. Soc. N.S.W., Vol. LV, 1921, p. 237.

Physiography of the Upper Hunter.

The country between Scone and the Barrington Tops represents a plateau in a state of mature dissection as a result of the activities of the Upper Hunter and its tributaries. The Barrington Plateau, which shows a fairly level skyline, sends out many long spurs like ribs towards the lower ground, and these in turn have their sides fluted with many gullies. The more or less isolated hills and ridges rising in the broad valleys are remnants of the plateau.

The Upper Hunter River at Moonan Flat and for some miles upstream is in a state of early maturity, but its tributaries, even the larger ones, such as Moonan Brook and Dry Creek, are distinctly youthful. The Upper Hunter at Moonan Flat is about 1000 feet above sea-level. It is a river of innumerable bends, consequently it has quite a surprising extent of alluvial flats. Even at the Glenrock crossing, about 8 miles up from Moonan Flat and about 25 miles from its source, the stream flows through 10 or 15 feet of its own alluvium. Moonan Flat settlement itself occupies an extensive flat on the inside of a great curve in the stream.

In places the river flows through a gorge, probably due to the presence of a bar of relatively hard rock across its path. Downstream the maturity of the river is much more advanced, as at Belltrees and Arden Hall. Here indeed its appearance is that of a meandering stream entrenched in a wide mature valley. Just up the river from Belltrees, for example, the road crosses a hairpin bend in the river twice; and on the road between the two crossings there are river-gravels lying on solid rock at a height of about 70 feet above the present stream-level. Mr. Andrews* considers that "the Upper Hunter at Bell-

*loc. cit., p. 523.

trees occupies a channel excavated several hundreds of feet below an older and very wide valley-floor, the upper and enveloping valley appearing to be about 2000 feet deep." It is evident, therefore, that at least two uplifts are indicated by the physiography of the valley.

During a rapid trip the author could find no evidence that the general direction of the stream as a whole had been influenced by the directional structures of the rocks. The river, indeed, transgresses the trend of the country over the greater part of its course.

The occurrence of so much mature physiography behind or to the east of the high barrier of Kuttung rocks from Wingen southwards is probably to be attributed to the fact that the Kuttung rocks consist largely of very resistant acid lavas, conglomerates and cherty varves, while the rocks to the east, both Burindi and Devonian, are on the whole softer and more easily eroded.

The south-westerly course pursued by the Upper Hunter between Muswellbrook and Denman, where it joins the Lower Hunter, has been interpreted by Professor Griffith Taylor as indicating that the former stream was once a tributary of a westerly-flowing river and that it has been captured by the Lower Hunter. But it seems possible that the "boathook bend" or "barbed junction" which characterises the confluence of the two rivers may have been brought about by other and less drastic means.

Although the present course of the Upper Hunter is south-westerly, its valley, or rather the broad valley of its ancestor, stretching from the Carboniferous hills on the east to the Hawkesbury sandstone cliffs on the west, has a distinctly meridional trend. The ancient river, when, having reached a state of grade, it started to widen its valley, found eastward planation checked by the barrier of Carboniferous rocks, which are very resistant

as a rule, and continue so well down below the present erosion level. On the other hand the effectiveness of the Hawkesbury sandstone barrier on the west was weakened by its resting on the soft coal-measures, so that sapping would gradually widen the valley in a westerly direction. This same circumstance which forced the Upper Hunter to the west would also force the Lower Hunter to the south-west. It may be also that the present course of the Upper Hunter is in part due to the dip of the rocks, since the river on emerging on to the soft westerly-dipping coal-measures would naturally tend to erode longitudinally parallel to the strike and laterally in the direction of dip, the resultant course being a compromise between the two.

Age and Relations of the Fault.

There is sufficient stratigraphical evidence available to enable us to set some limits to the geological age of the Wingen fault. It is fairly certain from field observations that the base of the Hawkesbury sandstone is at a considerably lower level than the tops of the Carboniferous hills, and this conclusion is confirmed by an examination of the recorded heights of railway stations and of some of the Carboniferous peaks. For example the peak known as Black Top, about four miles E.N.E. of Parkville, is 3297 feet high, whereas Murrurundi, which, according to the geological map of the State, is just at the base of the Hawkesbury sandstone, is only 1548 feet. It is a pretty reasonable conclusion, therefore, that the fault is post-Triassic in age, although, of course, there is a possibility that the basin in which the Hawkesbury sediments were laid down was bounded eastwards by a pre-Triassic Wingen fault.

The evidence is not, however, sufficient to enable us to tell the age of the fault relatively to that of the

Tertiary basalt. Some of the Carboniferous peaks east of Scone are (*fide* Mr. G. D. Osborne) capped with basalt, which was probably formerly continuous with that capping the Hawkesbury sandstone north and north-west of Wingen. Some of the basalt on the western side of the fault seems to be at a much lower level than the base of that lying to the east, but this might be interpreted as indicating either that the basalt was faulted, or that it was outpoured after the faulting and while the physiographic relief produced thereby was still pronounced; in this case the scarp as it is seen to-day would be partly a revealed fault-scarp.

On the whole it seems more probable that the fault is of pre-basalt age. The fact that there is a considerable thickness of Permo-Carboniferous sediments represented on the western side of the fault while, so far as is known, there are no traces of them on the Carboniferous hills, would imply that erosion had cleared these latter of all traces of overlying rocks before the basalt was erupted.

It seems possible that a definite solution of this problem of the relative ages of faulting and vulcanicity may be got by examining the country near Murrurundi.

Owing to insufficient data, it is useless to attempt an estimate of the throw of the Wingen fault. Nevertheless it is certain that this must be pretty considerable, since in some places Upper Marine Permo-Carboniferous rocks are brought against Kuttung lavas. Neither is it certain whether the fault is normal or reversed, although a normal fault would appear to be indicated in some places along the fault-plane, where the Carboniferous rocks are dipping westwards at angles of about 40° to 50°, while the Permo-Carboniferous rocks on the western side are dipping westwards likewise at very high angles. This state of affairs, which is purely local, would naturally

result from dragging of the strata along the plane of a normal fault. The possibility suggests itself that this Wingen fault is really the northward continuation of Professor David's Elderslee fault. Of course confirmation of this view would require that the continuation of the Wingen fault, or fault-zone, should be traced south, but it is significant that in both cases the fault separates Carboniferous and Permo-Carboniferous rocks, and that the boundary line between these two formations, as shown on the geological map of the State, forms approximately a simple curve from Mt. Tangorin to Wingen. If this tentative correlation should prove to be correct it has obviously an important bearing on the geological age of the faulting in the Maitland coal-field.

But an examination of the geological map of the State strongly suggests the further possibility that the Wingen fault, after making a curve between Wingen and Murrurundi, continues in a N.N.W. direction, and is identical with that described by Professor Benson* as bounding the Carboniferous rocks at and northwards from The Gap, about three miles west of Werris Creek, where the western limb of a great syncline of Kuttung rocks ends abruptly against a stretch of black-soil plain.

Physiographic History.

From the foregoing notes it is possible to reconstruct some of the stages in the evolution of the present physiography of the area dealt with. In post-Triassic times, after the consolidation and uplift of the Hawkesbury sandstones, a fault occurred, with a considerable throw to the west, cutting through Permo-Carboniferous and possibly Triassic sediments. Considerable denudation of the high country to the east followed, and possibly a

*Proc. Linn. Soc. N.S.W., Vol. XLV, 1920, p. 285.

peneplain was produced. Sometime during the Tertiary period basaltic eruptions on a gigantic scale took place, producing flows which may have exceeded 2000 feet in maximum thickness. The greatest thickness of these appears to have been to the north and east, in the Liverpool and Mount Royal Ranges, and they covered the country at least as far south as Muswellbrook. The consequent streams brought into being as a result of this vulcanicity, and revived by subsequent uplifts, included among others the Upper Hunter and its tributaries, which have very thoroughly dissected the plateau, so that except for the outliers capping isolated hills and ridges the basalt now appears only along the eastern and northern rims of the Upper Hunter basin. The maximum uplift was of the order of 3000 feet, sufficient to bring the Barrington plateau to its present elevation of about 5000 feet.

The dissection in the course of time revealed once again the old fault-plane, and the valley now occupied by Dart Brook, Middle Brook and Kingdon Ponds may be regarded as a subsequent tributary valley whose direction was determined, after the erosion of the basalt, by the fault and by the sub-meridional strike of the Permo-Carboniferous strata.

With respect to the Carboniferous country between Aberdeen and Moonan Flat the Upper Hunter is to be regarded as a superimposed stream, whose direction was determined originally by the slope of the basalt surface. It would be difficult, on any other hypothesis, to explain why the river should take its present course from the relatively soft Devonian and Burindi sediments through the hard barrier of Kuttung rocks on to the soft Permo-Carboniferous strata.

Economic Effects.

The broad mature valley and fertile flood-plain of the Upper Hunter upstream from Aberdeen have attracted considerable settlement. Where the valley narrows somewhat, as nearer Moonan Flat, the serpentine windings nevertheless have produced alluvial flats which provide much scope for the agricultural activities of the settlers, and for some miles up beyond Moonan Flat on the main river, and even too along its tributary, Moonan Brook, considerable cultivation of the high-level alluvium is to be seen. It might also be mentioned that the long spurs projecting from the plateau make excellent sheep and cattle country when ringbarked. The windings of the river have, however, proved to some extent an obstacle to communication, and have rendered very expensive the making of a "dry" road, since the elimination of crossings necessitates either the construction of bridges or else the making of cuttings in the steep, almost vertical, banks on the convex sides of the bends.

As regards the sub-meridional valley between Muswellbrook and Wingen, one obvious effect of the erosion along the revealed fault-scarp has been to provide an easy route for road and railway; in conjunction with the faulting, the inferior resistance of the Upper Coal-measures has been the principal factor in defining the valley. Even beyond Wingen the influence of the soft coal measures continues to be felt, for the railway, which negotiates the Liverpool Range at its lowest part, does so through Murrurundi and Ardglen, over coal-measure rocks.

It must be remembered, too, that it was the Wingen fault that caused the upturning of the strata of both the Upper and the Greta coal-measures along this valley, thus rendering their contents accessible.

Conclusion.

An attempt has been made in these notes to give a necessarily meagre and incomplete account of what is evidently an extremely interesting region, in the hope of directing attention to it and stimulating further research. In particular it seems highly desirable that more detailed work should be done to ascertain the extent, displacement and exact geological age of the fault, which, apart from its economic effect, may prove to be one of the grandest and most significant tectonic features in the geology of our State.

Note—The map accompanying this paper is copied, with slight modification, from the Geological Map of New South Wales, issued by the Department of Mines, Sydney, in 1914.

NOTES ON BORONIA IN THE PINNATAE SECTION, WITH A DESCRIPTION OF A NEW SPECIES.

By Edwin Cheel,

Botanist, National Herbarium, Sydney.

(*Read before the Royal Society of New South Wales, Sept.* 3, 1924.)

During a visit to the northern rivers of this State in company with Dr. T. Guthrie and Mr. A. D. Ollé in 1916, an interesting *Boronia* was observed in the neighbourhood of Broadwater, which at first glance might easily be mistaken, in general appearance, for *Boronia pinnata*, but when closely examined it was at once seen that the branches and branchlets were more or less pubescent or pilose, and the leaflets smaller, whereas those of *B. pinnata* are coarser and thicker in texture, and all parts of the plant are perfectly glabrous.

In comparing it with other species of the Pinnatae Series, I find that it approaches *B. microphylla* Sieb., which, although described by Bentham as "a low stunted shrub, glabrous but often very glandular", is more often found to be minutely but distinctly hispid on the juvenile branches.

Under *B. pinnata* the following well-marked species were united as synonyms by Mueller(4) :—*B. pilosa Labill.*, *B. variabilis* Hook., *B. tetrandra* Hook., *B. anemonifolia* Paxt., *B. Fraseri* Hook., *B. Gunnii* Hook., and *B. citriodora* Gunn. Bentham(1) regards *B. microphylla* Sieb. as a distinct species, and gives the Blue Mountains, Parramatta and Upper Clarence River as the habitat, but admits the latter station as rather doubtful, the specimen being very

incomplete. Mueller(4) states that "*B. microphylla* stands in close relationship to *B. algida,* from which it only differs in leaves with several pairs of leaflets, in hairy filaments and possibly in fruit". Whilst I am willing to admit that there is a close relationship between the two latter species, I find no difficulty in separating them in the herbarium.

I am also of the opinion that the Clarence River plants referred to by Bentham under *B. microphylla* should be included under *B. safrolifera,* and have accordingly drawn up a description for the proposed new species, and offer some notes on the closely related species, including the var. *Muelleri* of *B. pinnata,* which I suggest is worthy of specific rank.

BORONIA SAFROLIFERA, *sp. nov.*

Plants slender, more or less decumbent, the branches distinctly pubescent or shortly hispid. Leaves pinnate, leaflets 7-11. Flowers of a pink colour, usually singly, but occasionally in pairs, or rarely more than three in cymes in the axils of the leaves. Stamens 8, four slightly longer than the others, filaments more or less clothed with rather long hairs. Stigma short, smaller and not globose as that of *B. floribunda,* with which it appears to be closely allied.

Habitat: In peaty bogs at Coff's Harbour (J. L. Boorman, June, 1911); Broadwater, Richmond River (E. Cheel, Dr. T. Guthrie and A. D. Ollé, September, 1916).

To the above we may also add *B. pinnata* of Scortechini(7) [but not of Smith] from Stradbroke Island and Nerang Creek, Queensland, as from an examination of a very old specimen from Stradbroke Island, collected by the late F. M. Bailey, now in the National Herbarium, Sydney, labelled *B. pinnata,* I am inclined to regard it as being *B. safrolifera* rather than *B. pinnata.*

Although the plants of this species have at first sight a superficial resemblance to those of *B. floribunda* and *B. pinnata,* they appear to be nearer to the larger leaved form of *B. microphylla,* as in all the specimens examined of *B. pinnata, B. floribunda, B. Muelleri* and *B. thujona,* I have failed to find any traces or semblance of hairs or pubescence. The odour of the leaves when bruised somewhat resembles that of safrol.

BORONIA MUELLERI, *sp. nov.*

(*B. pinnata,* var. *Muelleri* Bentham.)

Bentham(1) regarded this plant as a variety of *B. pinnata,* and gave the following description:—

"Leaflets in distant pairs. Flowers nearly as large as in the Port Jackson specimens, but the filaments much less hairy, the anthers not at all apiculate, and I am unable to detect any dimorphism. The stigma minute or slightly capitate."

The localities given by Bentham are:—Sources of the Bunyip River, in the Grampians, near Portland Bay and towards the mouth of the Glenelg, Victoria. Through the kindness of Mr. W. Laidlaw, Government Botanist of the National Herbarium, Victoria, I have had an opportunity of examining the original specimen collected by F. von Mueller on the Bunyip Creek, as well as a specimen from Labertouch, Longwarry district, Victoria, by Mr. P. R. H. St. John in November, 1917, and, having carefully compared them with *B. pinnata* Sm., which is the common species in the Port Jackson district, I have no hesitation in saying that the Victorian plants are distinct from those in the coastal areas in the neighbourhood of Sydney. A sample of oil from the specimens collected by Mr. St. John in Victoria has also been examined by Mr. H. G. Smith(9), who has published the results of his examination under the name *B. pinnata.*

It is interesting to note that the aromatic odour of the Victorian plant has attracted the attention of Victorian botanists, for we find the following statement made by Ewart(2):—"The fragrant oil of many species might be used in perfumery, and although none are so strongly scented as the West Australian *B. megastigma* or the Victorian *B. pinnata*, they might improve under cultivation."

It would appear from the above remarks that the oil contained in the Victorian plants is quite distinct from that of the Port Jackson or Sydney district plants, as the oil from the latter cannot be regarded as pleasant. It may be, however, that when carefully compared with that of *B. thujona* Penfold and Welch(5), that the plants of the latter are not specifically distinct from *B. Muelleri*, as I am unable to separate these two species by any well-defined botanical characters, and in both species the oils have what may be regarded as a pleasant odour, and not acrid, as that of *B. pinnata*. The specimens mentioned by Mueller(4a) from Upper Clarence River under the name *B. pinnata*, as well as some specimens in the National Herbarium, Sydney, from Port Stephens, collected by Mr. J. L. Boorman, labelled *B. anemonifolia* by the late Mr. E. Betche, appear to belong to this species.

Boronia microphylla Sieb.

The original description of Sieber(8) is in Latin, and may be freely translated as follows:—"Leaves with six pairs of leaflets, leaflets minute, obovate, mucronate. Peduncles in the upper axils." It is also referred to by Hugel(3) and Reichenbach(6), who gives a figure which I have not seen. Bentham(1) quotes Sieber's specimen (No. 302), giving the Blue Mountains as the locality, also Parramatta and Upper Clarence River. With regard to the Clarence River specimens, Bentham states, *l.c.*, "The

latter station rather doubtful, the specimen being very incomplete. F. Mueller unites this species with *B. pinnata,* but as far as I have seen, the difference in foliage appears constant."

Then we have a reference to this species by Woolls(10), who gives Mudgee as a locality.

From an examination of the material in the National Herbarium I find that it is fairly common on the Blue Mountains, ranging from Wentworth Falls to Lithgow and also at Jenolan Caves. It is also to be found on the Main Southern Line, specimens being represented from Hill Top, Braemar and at Nerrigundah and Moruya. In the New England district it appears to be fairly common, as there are specimens from Emmaville, Boonoo Boonoo, Capertee, Torrington and Deepwater.

A specimen in the National Herbarium, Sydney, labelled *B. microphylla* from Wallangarra is *B. granitica.*

The specimen mentioned in *B. Fl.* from Upper Clarence River probably belongs to *B. safrolifera.*

Bibliography.

(1) Bentham, G., Flora Australiensis, I., p. 314.
(2) Ewart, Prof. A. J., Fl. N. Territory, pp. 156-157, 1917.
(3) Hugel, C. L. B. de Enum. Pl. Nov. Holl., 1837, p. 16.
(4) Mueller, F. von. Plants. indig. to the Colony of Vict., I., 1860-62, pp. 100, 115 and (a) 229.
(5) Penfold, A. R., and Welch, M. B., Journ. Roy. Soc. N.S.W., LV., 1921, p. 196.
(6) Reichenbach, Icon. Exot., t. 71.
(7) Scortechini, Rev. B., Proc. Linn. Soc. N.S.W., 1881, p. 159.
(8) Sieber, In Sprengel's Syst. Cur. Post., 1827, p. 148.
(9) Smith, H. G., Journ. Roy. Soc. Vict., XXXII., 1919, p. 14.
(10) Woolls, Rev. W., Proc. Linn. Soc. N.S.W., 1885, p. 457.

THE CHANGE OF RESISTANCE OF MOLYBDENITE DUE TO LIGHT.

By S. L. Martin, B.Sc.
Communicated by Professor O. U. Vonwiller.

(Read before the Royal Society of New South Wales, Sept. 3, 1924.)

Introduction.

A number of workers, chief among whom is Coblentz*, have noticed that the resistance of molybdenite is decreased when light is incident on it. Professor Vonwiller† has shown that the apparent failure of molybdenite to obey Ohm's Law is only due to the comparatively large contact resistances at the points where the current enters and leaves the specimen. If these resistances are eliminated, molybdenite obeys Ohm's Law. In view of this, it becomes of interest to see if the light effect observed by Coblentz and others is really due to the contact resistances.

The following passage taken from a paper by Coblentz lends colour to this view:—

> "In the course of this investigation it was observed, as already mentioned, that samples of molybdenite, which are photoelectrically sensitive, have a considerably higher electrical resistance than samples which are not sensitive to light. Moreover the conductivity of the insensitive samples was found to be quite independent of the direction in which the current passed (lengthwise) through the crystal. On the other hand, samples which are sensitive photoelectrically were found to possess a much higher conductivity when the electric current (from a four-volt battery) was passed in one direction than when it was passed in the opposite direction through the crystal."

* Proc. Phil. Soc. Wash., Feb. 3, 1917.
Journ. Wash. Acad. Soc., 7, p. 525, 1917.
Bureau of Standards Sci. Papers, 14, p. 594, 1918.
Bureau of Standards, No. 338.

† This Journal, Vol. LV., p. 220.

Experiments carried out by the writer in the Physical Laboratory of the University of Sydney during 1923 to decide this point are described in this paper.

Apparatus and Method.

A thin strip of molybdenite, generally about 4 cms. long, 1 cm. wide and 0.001 cm. thick, was taken and copper deposited electrolytically on it on both ends; on to the deposits wires were soldered. It was found that this method reduced the contact resistance practically to zero. Almost at the end of these experiments it was found possible to solder wires directly on to the molybdenite if tallow were used as a flux. The specimen was connected in series with a resistance, R, of the order of 10^4 to 10^5 ohms, another resistance r, equal to 300 ohms and a two-volt accumulator. Copper strips were firmly clamped at two points on the molybdenite between the copper deposits and wires led from these strips to a potentiometer, so that the potential difference between these two points could be found. Wires also led from the resistance r to the potentiometer, enabling the current through the molybdenite to be determined. These copper strips were shielded from the light by means of ebonite screens; shielding was necessary because it was found that when light fell on the contact a big apparent change in resistance took place, probably a thermo-electric effect. When the contacts were covered up, however, the change was greatly reduced.

The specimen was placed in a suitable holder in which it could be illuminated by a 100 c.p. pointolite lamp placed above it, the intensity of illumination being varied by altering the distance. Screens provided with suitable apertures, placed between the lamp and the molybdenite, ensured that only the portion of the latter between the two copper strips was illuminated, all junctions and contacts being shielded from the light. A glass dish

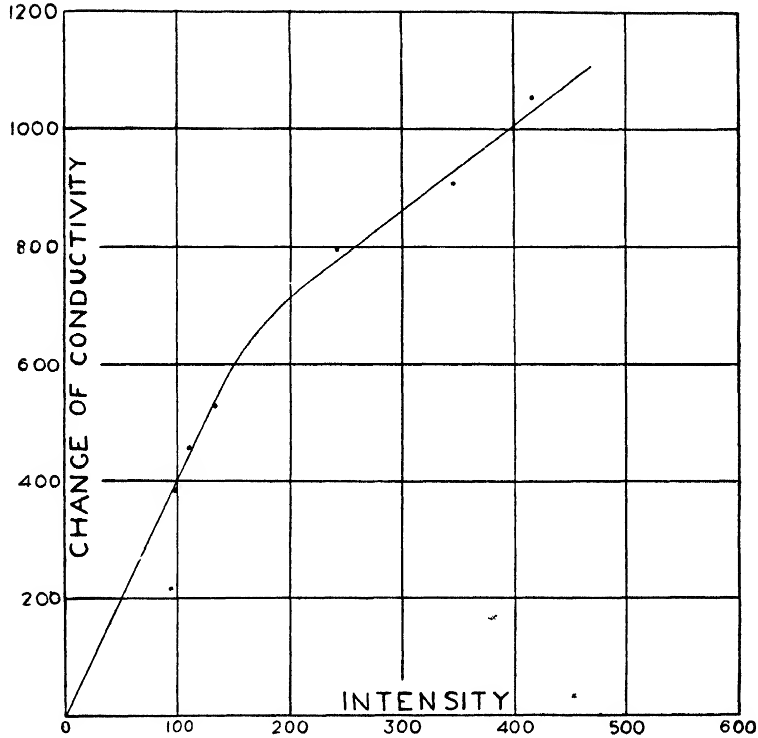
containing water to a depth of one centimetre was placed in the path of the light to absorb heat rays. The lamp was left on continuously during observations, the specimen being illuminated or shielded by moving an opaque screen.

Readings were taken as follows: After having adjusted R to the required value, readings of the potentiometer were taken necessary to balance the fall of potential between the copper strips on the molybdenite. Exposure of the specimen to the light then followed, and it was found that the balance of the potentiometer was disturbed, the amount of the disturbance being noted. Early in the experiments it was noted that a small e.m.f. existed between the copper strips when it was exposed to light and no current was flowing through the specimen. Thus, in order to determine whether the effect of light is to decrease or increase the resistance of the specimen, it is necessary to know the magnitude and direction of this latter residual effect. It was determined frequently throughout the experiment and was found to alter irregularly, although the irregularity was generally within the limits of error.

Results.

It was found that in every case the conductivity is increased, the amount of the increase being independent of the direction of the current through the specimen. For small current densities, less than about one-tenth ampere per sq. cm., the change of conductivity for a given intensity of illumination was independent of the magnitude of the current, but for larger currents the change increased as the current increased.

Experiments were made to determine the relation between the change of conductivity and the intensity of the light. Results obtained with the specimen tested most exhaustively are given in the accompanying table and represented graphically in the figure, arbitrary scales being



used. This specimen was about 0.001 cm. thick, and the change of conductivity produced by a 100 c.p. pointolite lamp at a distance of 75 cms. was about one part in 500.

It will be seen that initially the relation between the intensity of illumination and the change of conductivity is a linear one, whilst for the higher intensities the change becomes proportionately less. This result, however, must not be accepted as conclusive, since definite results were only obtained with one specimen; results obtained with other preparations tended to verify this, but it seemed that the departure from the linear relation occurred with smaller intensities than in the case quoted above.

Intensity. I.	Change of Conductivity. C.	$\frac{C}{I}$
98	388	3·95
110	455	4·14
132	526	3·98
161	660	4·10
243	795	3·27
345	909	2·64
434	1050	2·42

This conductivity change being so small, it was thought that perhaps it might be accounted for by the rise of temperature caused in the specimen by its exposure to the light. This view becomes tenable when we consider that the effect of heating the specimen is to decrease its resistance. From values of the temperature co-efficient of resistance given by Professor Vonwiller*, it was calculated that a rise of 0.1 degree is sufficient to account for the change.

To test this point the water jacket was removed and the deflection of the galvanometer observed on exposing the specimen; it was found that within the limits of error the deflection was the same as when the water jacket was present. The effect of the light on a thermopile was then observed (*a*) with the water jacket between the source of light and the thermopile, (*b*) without the water jacket; the galvanometer deflection without the water jacket was five times as great as the deflection when the jacket was there. These results indicate that the visible part of the spectrum is the part which is responsible for the changes recorded.

Spectral Distribution of the Effect.

Having established the fact that there is a genuine light effect on the resistance of molybdenite, it became of interest

* Loc. cit.

to know to what extent the various components of white light affect the change. It must be borne in mind, however, that these experiments are in the main qualitative, and lay no claim to any great accuracy. One source of error lay in the fact that since Wratten filters were used, it was impossible to obtain homogenous light. Wratten filters F, C and H were used, filter F allowing red rays to pass mainly. The intensity of light transmitted through each filter separately was measured on a thermopile. The magnitude of the conductivity change when each of the screens was interposed was then found; results are given in the following table:—

Distance of Lamp from Specimen.	Change of Conductivity. Intensity of Light.		
cms.	Filter F.	Filter C.	Filter H.
72·7	1·56	·38	·38
72·7	1·52	·71	·75
49·4	1·58	·62	·74
49·4	1·54	·73	·71

Owing to the small order of accuracy of these results, nothing further than the general inference that the red end of the spectrum is the most effective part, can be obtained.

Incidental to these observations on the spectral distribution, experiments on the transmission of the visible spectrum through molybdenite were carried out. These indicated that all wave lengths were transmitted to the same extent, this being the same conclusion as that at which Coblentz arrived.

Summary.

Experiments were carried out to see if the change in resistance of molybdenite, when light was incident on it, was due to an actual change in conductivity, or due only

to contact effects. It was found that there was an actual change in conductivity, due to light, but that if the contact resistance were large and light fell on the contacts, this change was masked by a very much larger effect. In a specimen about 0.001 cm. thick, a 100 c.p. pointolite lamp at a distance of 75 cms. increased the conductivity by about 1 in 500, and the magnitude was independent of the direction of flow of the current. For small currents, the change was constant.

For small intensities of light the change was also found to be proportional to the intensity. The red portion of the spectrum is more effective in increasing the conductivity than the blue, and experiments carried out on the tranmission of the various wave lengths through molybdenite go to show that all wave lengths are equally transmitted.

EVIDENCE OF A NEGATIVE MOVEMENT OF THE STRAND LINE OF 400 FEET IN NEW SOUTH WALES.

By T. Hodge Smith and Tom Iredale.
(Contribution from the Australian Museum.)

(With Plate VII. and two Text-figures.)

(Read before the Royal Society of N.S. Wales, Sept. 3, 1924.)

The nature of the evidence of a negative movement of the strand line of four hundred feet in New South Wales is both geological and biological. So much evidence has been collected that it is thought advisable to place it on record.

Part 1.—Geological Evidence by T. Hodge Smith.

This is based on the lithological character of sandstone slabs dredged from the seventy fathom line, the nature of this line and sections of the drowned river valleys of Port Jackson and Georges River.

Through the kindness of the New State Fish and Ice Company, and particularly of the manager, Mr. C. W. Mulvey, and Captains H. Flett and J. Forder, of the trawlers, I have been able to examine a number of irregularly shaped sandstone slabs dredged at various points along approximately the seventy fathom line east of New South Wales.

These slabs are composed of coarse rolled sand grains and are sometimes very compact. Almost always they are highly fossiliferous and often these fossils, or perhaps more correctly sub-fossils, occur in bands, intercalated with bands of very compact non-fossiliferous sandstone. Plate VII. shows a portion of one of these slabs dredged

from the seventy fathom line east of Montague Island and gives a very good idea of the fossil content and coarseness of the sandstone. The largest boulder so far brought in measured six feet by three feet six inches by eighteen inches, and comes from the seventy-five fathom line east of Narrabeen. This slab was penetrated in a number of places by irregular branching burrows which were almost circular in cross-section, the major and minor diameters, in general, measuring one and a half inches and one and a quarter inches, respectively. The whole slab, including the burrows, was coated with iron oxide (limonite). It is evident that it was not broken off an outcrop of rock by the trawling net, as no point of attachment existed, and this applies to all the slabs that I have examined. It is important to note that two slabs obtained from the seventy-five fathom line are not as coarse in texture as the remainder from the seventy fathom line.

These slabs have been dredged up for a distance of about two hundred miles along the coast, while they are entirely confined to the 70-75 fathom area. So far, they have been obtained from east of Long Reef, Botany Bay, Kiama, Ulladulla and Montague Island (figure 1).

It is of interest to note that slabs of recently formed sandstone containing shells characteristic of our beaches to-day occur between tide-marks on the present-day shore line. I have examined some of these sandstone slabs on the beach immediately to the south of Long Reef, Narrabeen, in a direct line with Florence Avenue. No less than seven of these slabs were exposed at low tide when I visited the locality and they measured from ten to twenty-one feet in length. A corner of one of them was broken off and in the section so obtained it was seen that the character of the underlying beach sand and the sand grains of the rock were precisely similar in colour and

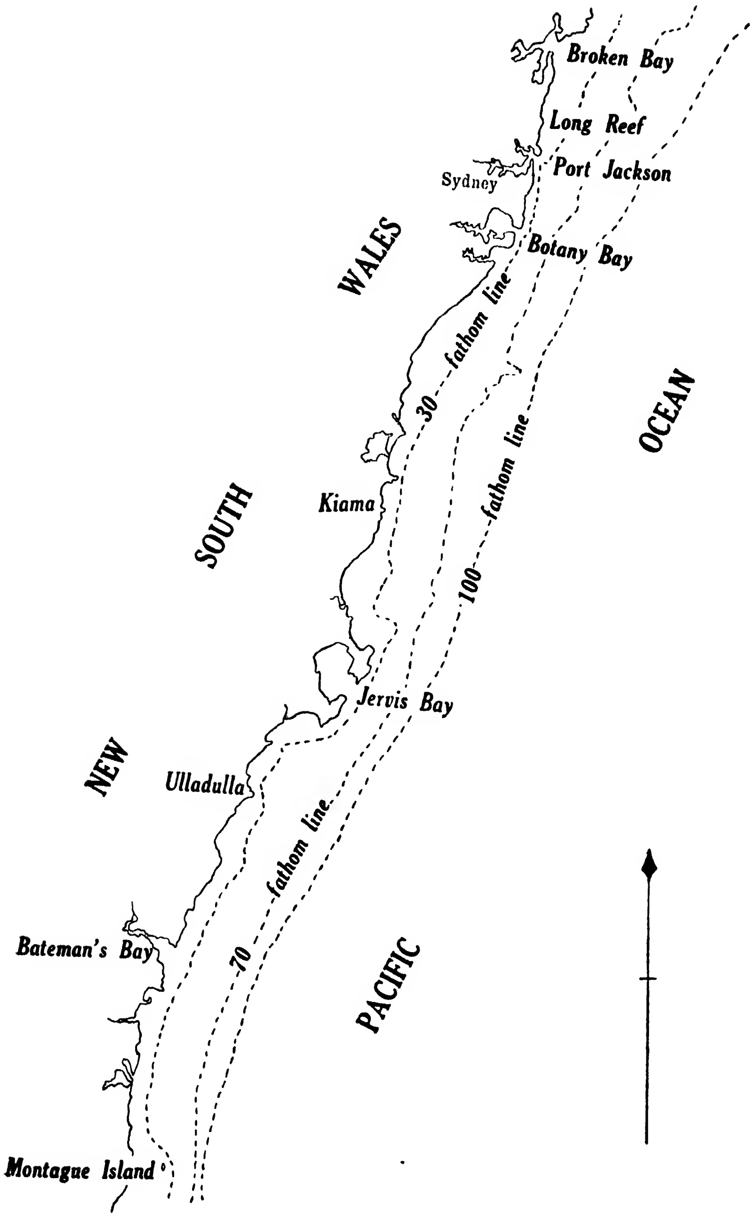


Figure 1.—Map of the area under consideration, showing localities where sandstone slabs have been found, and the 30, 70 and 100 fathom lines.

size, making the contact between the two difficult to distinguish. This suggests that these slabs have been formed probably *in situ* by the action of fresh water entering the sea at this point.

Lithologically the rock at Narrabeen matches the rock from the seventy fathom line, except that in one or two cases the latter is much coarser in texture. It would seem that the only conclusion possible is that these slabs have been formed at or near a sea shore.

A study of the Admiralty charts of this part of the coast reveals another interesting feature about this seventy fathom line. Repeatedly right along the region of this line and even beyond the distance under consideration, coarse sand, gravel, stones and sand are recorded, while inshore from this line such records are conspicuous by their absence. This, in itself, is highly suggestive of an old shore line.

A number of bores have been put down in Port Jackson at various times. The object has been to find rock bottom for the purpose of bridge piers, etc., and not with a view to ascertaining the contour of the old river valleys. Therefore, they can only represent the approximate sections. However, for the purpose of this discussion, this factor does not vitiate their value as the maximum depths given, if not correct, will not be overestimated but rather underestimated. I am indebted to officers of the various Government Departments concerned for making available plans and sections from which the reproduced sections (figure 2) were copied.

The first section is taken across Port Jackson from Milson's Point to Dawes Point. The bed of the original valley here is 151 feet below sea level. The second section is taken across Middle Harbour from Pearl Bay to Sea-

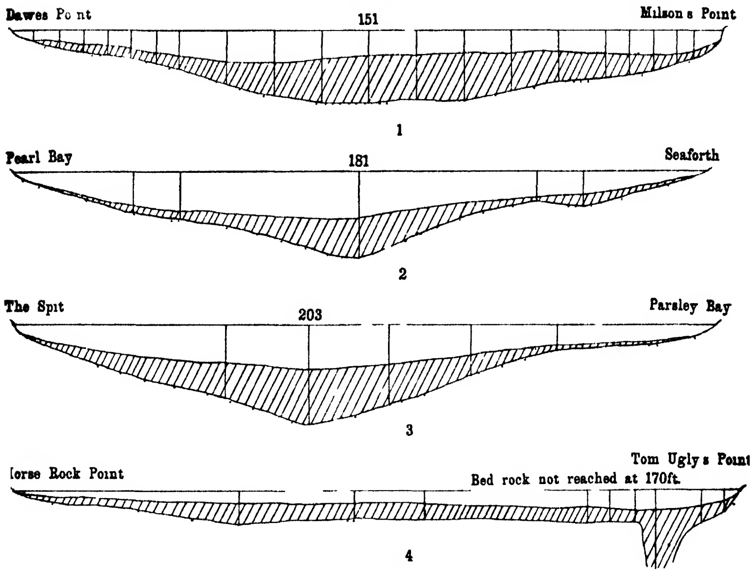


Figure 2—Sections across Port Jackson (1-3) and George's River (4). The vertical lines represent the position of the bores put down and the numbers are the maximum depths of those bores in feet. The hatchured portion consists of sand and clay and the dotted portion bedrock (Hawkesbury Sandstone). The datum line is low water ordinary spring tides.

forth, and here the bed of the valley is 181 feet below sea level. Section No. 3 is also taken across Middle Harbour, from The Spit to Parsley Bay, but a little further downstream, and shows a maximum depth of 203 feet. The original river valley now forming Middle Harbour was a tributary of the river now represented by the main harbour, and consequently the maximum depth of the sections of the former gives an indication of its junction with the latter. Section No. 4 is taken across George's River, which flows into Botany Bay. The bore put down in the deepest part of the section was abandoned at 170 feet without reaching rock bottom. These sections give measurements of the amount of subsidence below sea level

of the two drowned river systems of Port Jackson and George's River. The measurement of 203 feet for the bore at The Spit must necessarily demand a subsidence of at least the same amount. But if the whole area be elevated by this amount then the nearest point to the sea would be about ten miles, and it is to be remembered that these drowned valleys are not characteristically mature river valleys. It is, therefore, very unlikely that they had reached base levelling. On the other hand such gorges could be cut at sea level provided that there was a considerable amount of high land immediately behind. There does not appear to be any evidence of the existence of such highland, and therefore one may reasonably conclude from the evidence available that the negative movement of the strand line responsible for those drowned valleys was very considerably more than 203 feet. While this does not prove that there has been a movement of four hundred feet, it is certainly in harmony with the other evidence indicating a movement of such a magnitude.

From the palæontological evidence it seems fairly definitely established that the age of this movement is not pre-pleistocene, although Mr. F. Chapman states in official correspondence in regard to the rock dredged from east of Narrabeen that "it may be of late Pliocene age, since some of the forms are not exactly typical of the living fauna, or may be new". The rock dredged from east of Botany is in his opinion "in point of age either Pleistocene or Holocene (sub-fossil)".

So well established is the world-wide negative movement of the strand line due to oscillations of the sea level in connection with the Pleistocene ice age, that it seems necessary to reconcile this movement of four hundred feet with it. A careful examination of the soundings on the continental shelf reveals the fact that at about forty

fathoms there is a distinct steepening of the general slope of the shelf, indicating a pause in the movement. This break has been previously recognised and generally accepted as evidence of the world-wide change of sea level due to the Pleistocene ice age.

It is evident then that this major movement can be divided into at least two movements, of which one may be due to further oscillations of the sea level or to orogenic earth movement. They are so nearly equal in magnitude that it is very difficult to say whether the first or second movements were due to the world-wide change of sea level, and I am unable to find any evidence on this point.

It is known that local oscillations of sea level do take place corresponding to local changes of glaciation, but so far the magnitude of these movements is not known. With our present knowledge, it seems highly improbable that a change of sea level of two hundred feet due to glaciation could be limited to the area under consideration. Until evidence is produced of a similar movement at least affecting the whole of the Pacific Ocean, it seems necessary, for the present, to accept this negative movement of the strand line of four hundred feet as being divided into at least two movements, one of which is due to earth movements.

Accepting the seventy fathom line as the Pleistocene shore line, the continental shelf would be only a few miles wide at most. This suggests a subsidence of this old continental shelf, and in this connection it is interesting to note that on the Admiralty chart at latitude 35° 38′ at 112 fathoms, sand and stones are recorded and at latitude 36° 46′ at 109 fathoms coral sand. Unfortunately the majority of soundings beyond the hundred fathom line do not reach bottom, and consequently the evidence is not sufficiently conclusive on this point.

Part 2.—Biological Evidence by Tom Iredale.

The characteristic forms found in the boulders examined are as follows:—

Pecten meridionalis Tate.
Venericardia amabilis Deshayes.
V. bimaculata Deshayes.
Glycymeris tenuicostatus Reeve.
Limatula strangei Sowerby.
Cardium pulchellum Gray.
Gari livida Lamarck.
Macrocallista disrupta Sowerby.
Lioconcha angasi Smith.
Dosinia aff. *grata* Deshayes.
Arcoperna scapha Verco.
Neolepton novacambrica Hedley.
Antigona lagopus Lamarck.
Sigapatella calyptræformis Lamarck.
S. hedleyi Smith.
Turritella sp.
Terebra sp.
Estea bicolor Petterd.
Marginella mayii Tate.
M. ochracea Angas.
M. kemblensis Hedley.
Friginatica beddomei Johnston.
Astraea aurea Jonas.
Peculator verconis Iredale.
Cancellaria purpuriformis Valenciennes.
Cocculina tasmanica Pilsbry.

The slab examined from 70 fathoms off Montague Island (Plate VII.) is composed of coarse gravelly sand, suggesting the littoral debris of a rock edged beach. The sand is very familiar to the shore worker, and does not suggest any depth nor does it agree with sand from the middle of a long beach. The block shows the flat valves of a scallop (*Pecten meridionalis* Tate) in profusion, intermingled with other bivalves in less number, and rarely a few univalves are met with. Among the coarser patches minute molluscan shells may be seen, and these are apparently lying loose among the particles of sand and not crushed at all. The occurrence of the flat valves of the scallop with only a rare convex valve suggests that this block was formed in very shallow water near shore, the

scallops when dead separating into two pieces, and the wash of the waves driving the convex valves on shore leaving the flat valves behind. Near a shallow water scallop bed the convex valves may be commonly met with on the beaches, but very rarely can a flat valve be found. If a dredging in anything beyond ten fathoms be made near a scallop bed the valves will be found in equal numbers, or a majority of convex valves, according as the dredge works. The presence of a few odd rock-living gastropods indicate the vicinity of rocks. That the boulder was formed in very shallow water appears to be a necessary conclusion from examination of the mollusca content. So little is known exactly regarding the molluscan faunula of the continental shelf that it would be unwise to dogmatise, but collation of published results and examination of much unpublished material suggest a somewhat uniform fauna extending from off Green Cape in the South to Newcastle or higher in the North. The faunula living on the 40-70 fathoms ledge is of a deep water, compared with a littoral faunula, facies, but none of the characteristic forms of that faunula appear in the present rock. As an item of interest, living on the top of the rock were some of these 40—70 fathom mollusca, while the most remarkable feature of the slab shells, which may yet lead to important results, is their littoral southern facies. The deep water, 40—70 fathom, mollusca have proved to be very closely allied to the uppermost beds of the Murray Creek, now classed as Kalimnan (Lower Pliocene), so that they are scarcely separable. I have suggested that the best means of expressing the relationship would be the usage of a trinomial nomenclature, thereby neither affirming nor denying their specific status. These dwellers on the continental shelf of New South Wales appear to be of southern relationship, even when collected

as far north as Narrabeen. The molluscan content of the slabs under review cannot be separated in the majority of cases by even the most determined "Splitter" (*e.g.* myself) from recent species, but they must be compared with living species from Victoria or Tasmania, not Sydney.

Pecten meridionalis Tate.—In a paper published in the Linnean Society's Proceedings*, I have briefly indicated from an independent review of specimens, my results as being in complete agreement with those of Tate, propounded some forty years previously. Since that paper was written I have been accumulating more facts, and a large series of valves from Stockton near Newcastle, given me by Mr. A. Broadfoot, of Manly, who collected them, are all deep convex valves and separable at a glance from the Tasmanian *meridionalis.* The whole of the valves in the slab from off Montague Island agree in the most minute detail with South Tasmanian specimens, and reach very large dimensions, the largest one unbroken measuring 155mm. × 124mm. There is no variation seen, but I have recorded that specimens from shallow water in Twofold Bay are intermediate in some of their features, and some shells since received from the same locality but from deeper water show more variation, but these do not agree with the slab shells.

Venericardia amabilis Deshayes.—This species is the next most common form and is associated with *V. bimaculata* Deshayes. While the former is abundant in shallow water in southern New South Wales, the latter is as common in the same station in South Tasmania, but is at present unknown from New South Wales.

Dosinia aff. *grata* Deshayes.—Two valves of a *Dosinia* are smaller than the specimens available for comparison

* Proceedings Linnean Society N. S. Wales, 1924, pt. 3.

from Victoria, but otherwise agree in sculpture and are not *crocea,* the common New South Wales form. The species *grata* has not otherwise been recorded from New South Wales.

Macrocallista disrupta Sowerby.—The specimens agree better with the South Tasmanian shells than with the New South Wales specimens regarded as conspecific.

Glycymeris spp.—This group causes more trouble than almost any other and I have endeavoured to untangle some of the skeins in my essay above noted. The valves seen in this boulder do not agree well with any of the forms, but some appear to belong to a form of *tenuicostatus* Reeve, recognised from South Tasmania. The others show teeth varying a little from recent shells I have so far examined, but none have the form of *cainozoicus* Ten.-Woods, the only fossil smooth species so far distinguished. On the beach at Narrabeen hundreds of valves of *Glycymeris* are washed up and these show three or four species. No long series from Tasmania has yet been examined.

Arcoperna scapha Verco.—This is a southern species, whose occurrence was unexpected, and its association with *Gari livida* Lamarck, *Antigona lagopus* Lamarck, *Cardium pulchellum* Gray, *Limatula strangei* Sowerby, *Lioconcha angasi* Smith and *Neolepton novæcambrica* Hedley, all commonly found in shallow water, suggests its occurrence here also.

Astraea aurea Jonas.—This is the most remarkable find, as this species is a rock-living form found between tide-marks in Victoria and Tasmania, but has not hitherto been found in New South Wales. It would have been regarded as a characteristic Adelaidean form, and its presence here allows of extraordinary surmise, which, however, is not the object of this note.

Cancellaria purpuriformis Valenciennes.—This is another southern form which has not yet been recorded from this State, and the other univalves met with, *Sigapatella calyptræformis* Lamarck, *S. hedleyi* Smith, *Friginatica beddomei* Johnston, *Peculator verconis* Iredale, *Estea bicolor* Petterd, *Marginella mayii* Tate, *M. ochracea* Angas, *M. kemblensis* Hedley, *Turritella* sp. and *Terebra* sp., may be regarded as of southern affinity in preference to northern origin.

The surmise hinted at may be developed at leisure, but this boulder points to a southern shoreline coexistent with the East Coast of Tasmania, which was drowned when Bass' Straits were formed, and this break took place recently, and the Kalimnan beds only belong to this period.

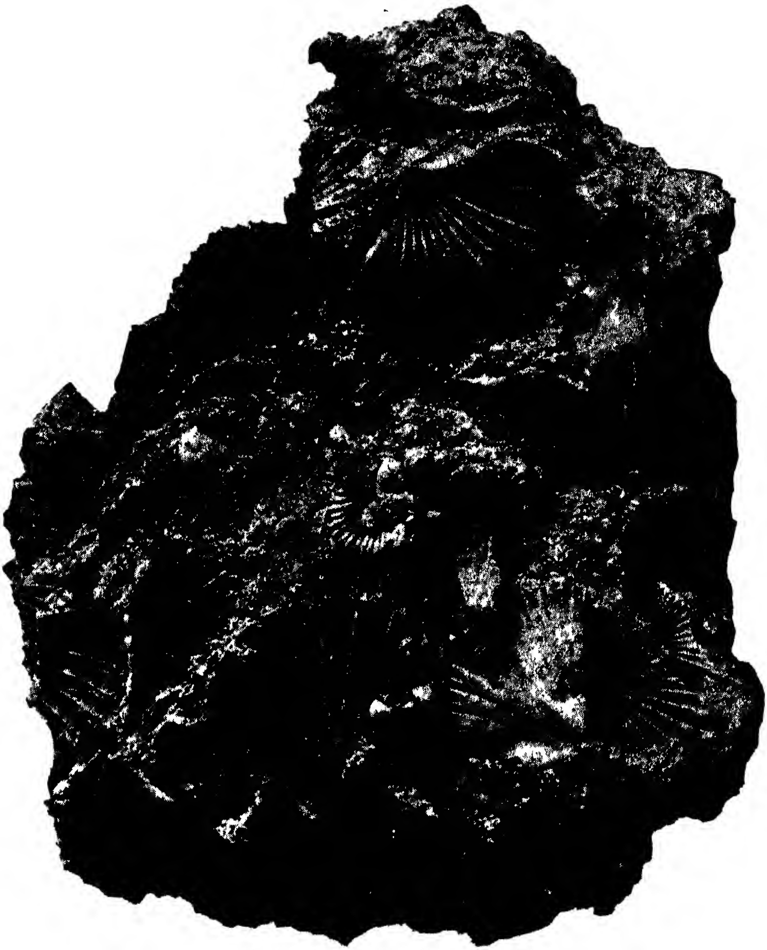
Conclusions.

From the Geological and Biological evidence we conclude that an old shore line exists along the 70 fathom line over the length under review.

This shore line probably exists both to the north and south of this area and from the Biological evidence it extended right down to the East coast of Tasmania.

This negative movement of the Strand Line took place certainly not earlier than Pleistocene and probably in quite recent times.

The movement may be divided into at least two stages of approximately the same amount.



G. C. Clutton, Photo.

Plate VII.—Portion of a slab dredged from the 70 fathoms line East of Montague Island, showing the abundant shell content (*Pecten meridionalis* Tate, *Venericardia amabilis* Deshayes, etc.) and the coarse texture of the rock.

NOTE ON THE STRUCTURE OF SOME EUCALYPTUS WOODS.

By M. B. WELCH, B.Sc., A.I.C.
Economic Botanist, Technological Museum.

(With three text figures.)

(Read before the Royal Society of N.S. Wales, October 1 1924.)

Of the commercial timbers on the market, no group is more difficult to identify accurately in the absence of botanical material than the so-called "hardwoods", which consist principally of Eucalypts. The large number of species producing merchantable timber, and the variation which sometimes occurs even in one species, so that weight, colour and texture overlap occasionally into the province of another species, make the problem often difficult. Macroscopical or empirical methods of identification are not altogether satisfactory, and other characteristics must be looked for as aids to the determination of woods which have superficial resemblances. It is therefore important that where possible some accurate method of classification should be devised, more especially with some of the commoner commercial timbers, since there is often doubt as to whether the terms of a specification are being complied with.

In this paper it is proposed to deal with the woods of *E. pilularis* Sm., Blackbutt; *E. microcorys* F.v.M., Tallow-wood; and *E. maculata* Hook, Spotted Gum. These three are typically distinct, and possess characteristics

which usually enable them to be separated. Sometimes, however, they show a similarity, so that when dealing with very small samples which are often submitted for examination, certainty of identification with ordinary methods is scarcely possible.

The woods of each are pale in colour, ranging from almost white to light brown. The texture is comparatively close, the pore size being variable. The weight per cubic foot varies from 50-60 lbs., depending on the condition of growth. The sap-wood is light in colour, the greatest width being in *E. maculata.*

Superficial characters.—In common with all other Eucalypts, these woods are diffuse porous. The pores on end section are usually in oblique rows in *E. pilularis* and *E. microcorys,* but in short radial rows in the case of *E. maculata.* The pores are evenly distributed, rarely single, usually in groups. The medullary rays are numerous, fine and indistinct, not prominent on the radial surface. Growth rings are not pronounced. Parenchymatous concentric bands are usually present in *E. maculata,* resembling in this characteristic *Angophora lanceolata* Cav.

Anatomical characters.—It is proposed to deal more fully with the anatomical characters of the woods, since undoubtedly certain microscopical structures are of marked diagnostic value, and are apparently constant. The only work in any detail dealing with the anatomical structure of the Eucalypt timbers which has so far been met with, is included in the exhaustive monograph on the Hardwoods of Australia, by R. T. Baker.*

*R. T. Baker, "Hardwoods of Australia and their Economics," Tech. Educ. Series No. 23, Sydney, 1919.

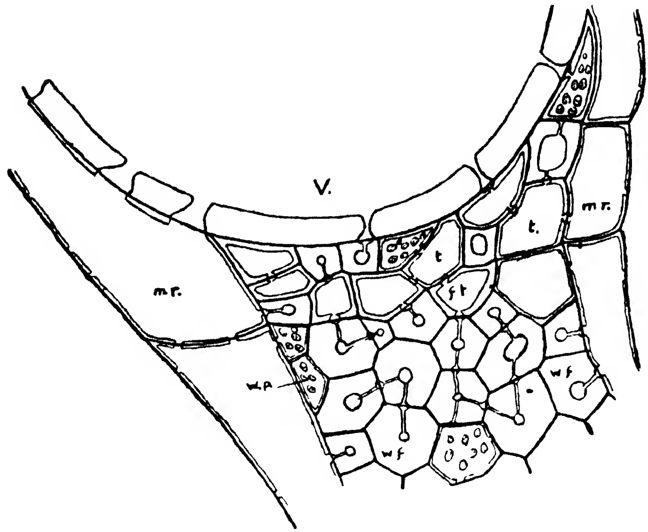


Fig. 1.

Transverse section of portion of the wood of *Eucalyptus microcorys*. v = portion of section of a vessel, shewing pitting; t = tracheid with bordered pits; *f.t.* = fibre tracheid, intermediate between the tracheid and the wood-fibre; *w.f.* = wood fibre, shewing small lumen and also small bordered pits; *w.p.* = wood parenchyma, the cell walls shewing simple pits; *m.r.* = medullary ray cells, also with simple pits. × 530.

The vessels (text fig. 2) are variable in size and shape, with a simple perforation at either end. The end projections are very pronounced, at times being as long as the vessel segment. The tracheids are irregular in shape (text fig. 3(a)), usually blunt ended with numerous bordered pits. Fibre tracheids (text fig. 3(b)) are thinner walled than the typical fibres, with more numerous bordered pits, and are prosenchymatous in shape. It is usual to differentiate between the wood or libriform fibres with simple pits and the fibre tracheids, but in the specimens examined (see also text fig. 1), the elongated

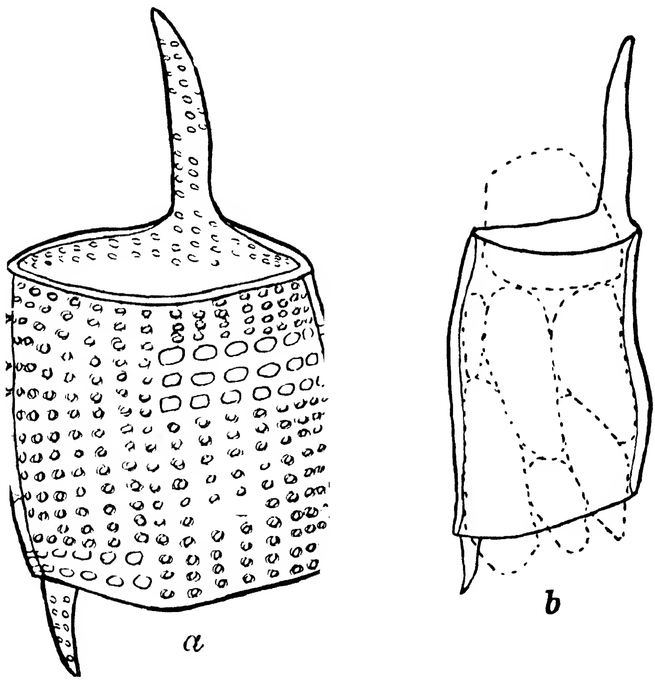


Fig. 2.

a = vessel segment, shewing arrangement of pitting and simple end perforation, also end projections. *E. maculata,* × 140. *b* = vessel segment, shewing tyloses, pitting not drawn. *E. maculata,* × 100.

thick walled fibre cells (text fig. 3(c)) possess what are regarded as bordered pits, and therefore resemble fibre tracheids. It is proposed to differentiate between these more sparsely pitted very thick walled cells, and the thinner walled more numerously pitted cells, which approach more closely to the typical tracheids. There is, however, no very clear line of demarcation, and these fibre tracheids seem to show gradations between the tracheid on one hand and the wood fibre on the other.

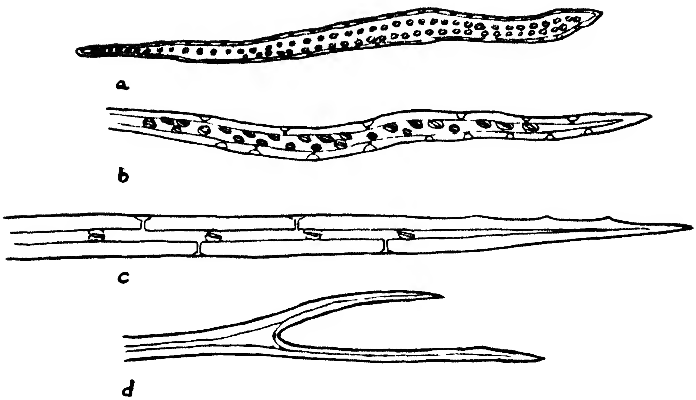


Fig. 3.

a = tracheid, shewing arrangement of bordered pits. *b* = fibre tracheid, shewing thicker walls and fewer pits. *c* = wood fibre, with very thick walls and few pits (not simple). *d* = branched fibre. All *E. maculata*. *a*, *b* and *d*, × 110; *c*, × 140.

E. microcorys F.v.M. Pores usually oval, more rarely circular in section, mean diameter 225μ, max. 300μ, min. 75μ, walls 7μ–16μ in thickness, end perforation simple, 5–10 per sq. mm. Pits numerous, small, bordered, or large and simple where in contact with the medullary rays. Tyloses often present in all vessels, or wanting. Tracheids 450μ–750μ long, 30μ–50μ in diameter. Wood fibres, non-septate, lumen very small, 750μ to 1950μ in length, walls up to 12μ in thickness, ends typically serrated, pitting prominent, bordered, slit-like. Fibre tracheids tapering, irregular in outline, thinner walled and more copiously pitted than wood fibres, $900\mu \times 20\mu$. Wood parenchyma, scattered or paratracheal, cells averaging 110μ by 20μ. Rays uniseriate, 2–16 cells high, often heterogeneous (in this respect differing from *E. maculata* or *E. pilularis*), the top and bottom cells of

the ray being larger when seen radially than the remainder of the ray parenchyma cells. Pits simple.

E. maculata Hook. Pores oval or circular in section, often unsymmetrical owing to grouping in short radial rows. $90\mu - 375\mu$ in diameter, walls $7\mu - 18\mu$ thick, end perforation simple, 5–8 per sq. mm. Pits small, bordered, large and simple in contact with medullary rays. Tyloses sometimes present in all vessels. Tracheids about $750\mu \times 45\mu$ with numerous bordered pits. Wood fibres often compressed radially, lumen small, $600\mu - 1650\mu$ in length, $5\mu - 18\mu$ in diameter, ends serrated, fibres rarely branched (text fig. 3(d)). Fibre tracheids about $825\mu \times 25\mu$ with numerous pits. Prosenchymatous cells are also present with thinner walls than the wood fibres, and possessing numerous bordered pits. Wood parenchyma, scattered or paratracheal, also often distinct concentric metatracheal bands up to 10 cells wide, cells $100\mu - 200\mu$ in length by $22\mu - 30\mu$ in width. Pits simple. This tissue is much more highly developed in the wood of this species than in the other two. Medullary rays, uniseriate or multiseriate, in this respect showing a very marked difference from the other woods. The rays are also much more numerous when seen in tangential section than in the other two species.

E. pilularis Sm. Pores usually oval in section, very variable in size from $55\mu - 240\mu$, walls $6\mu - 11\mu$ in thickness, 7–12 per sq. mm. Pits numerous, small, bordered, or large and simple in contact with ray cells. Tyloses often present in all vessels. Tracheids about $200\mu \times 30\mu$, showing graduations to typical fibre tracheids. Wood fibres non septate, $450\mu - 1{,}800\mu$ in length, $14\mu - 22\mu$ in width, ends typically serrated. Fibre tracheids numerous, about cells $750\mu \times 30\mu$. Wood parenchyma

in very small quantity, paratracheal, or scattered, and altogether much less than in the other species, cells about $200\mu \times 20\mu$. Medullary rays uniseriate, 2–16 cells deep, narrow in tangential section, $100\mu \times 20\mu$, or often shorter and broader. Pits simple, larger in contact with vessels.

Intracellular secretion.—A highly refractive substance, often globular, or at times almost filling the cell cavity and more or less granular in appearance, is found principally in the medullary rays, also in the wood parenchyma, tracheids and to a lesser extent in the lumen of the wood fibres. It is stained red with alkannin or Sudan III. These cell contents are very much more prominent in *E. microcorys* than in *E. maculata*, which in turn shows a greater quantity than in *E. pilularis*. The globules are insoluble under ordinary conditions in cold alcohol, but are soluble in chloroform or ether and in boiling alcohol. In certain of the ray cells of *E. microcorys*, the whole of the contents were stained, with the exception of several rounded clear spaces. It is suggested that the somewhat greasy nature of Tallow-wood is due to the presence of this oily body, which was very marked in all specimens examined, and which occurs to a very much less extent in the other two woods.

It has been pointed out in a previous paper* that an infusion of the wood of *E. maculata* gives practically no reaction with ferric chloride, whereas both *E. microcorys* and *E. pilularis* give a very decided reaction. This is also shown by the blue-black stain formed on a knife or razor when the two latter timbers are moistened and cut.

Those features, which are apparently of some value in the diagnosis of these woods, are:—

*Welch, "A Method of Identification of Some Hardwoods," Proc. Roy. Soc. N.S.W., Vol. lvi., 1922.

E. microcorys.	*E. maculata.*	*E. pilularis.*
Pores in oblique rows.	Pores in radial rows.	Pores in oblique rows.
Wood parenchyma present.	Wood parenchyma abundant.	Wood parenchyma rare.
Metatracheal bands absent.	Metatracheal bands present.	Metatracheal bands absent.
Rays uniseriate, usually heterogeneous.	Rays multiseriate, homogeneous.	Rays uniseriate, usually homogeneous.
Numerous oil globules.	Few oil globules.	Very few globules.
Marked reaction with iron salts.	Little reaction with iron salts.	Marked reaction with iron salts.

Other factors, such as pore size, length of fibres, relative proportion of fibre tracheids, etc., are apparently too variable to be of any great systematic value. It has been found that in the same piece of spotted gum, the mean pore diameter varied from 111μ near the heart to 157μ nearer the sap-wood.

A DESCRIPTION OF A NEW SPECIES OF EUCALYPTUS FROM SOUTHERN NEW SOUTH WALES.

By W. A. W. de Beuzeville and M. B. Welch, B.Sc.

(With Plates VIII., IX.)

(Read before the Royal Society of N.S. Wales, October 1, 1924.)

This species has been under observation for some considerable time, and recently an opportunity occurred of visiting the Big Badja Mountain, north-easterly from Cooma, where it was possible to make more extensive field observations.

Eucalyptus Badjensis, *sp. nov.*

A large forest tree, locally known as "Gully Ash," attaining a height of 100 feet or more. Bark persistent about half-way up the trunk, smooth above. Abnormal leaves opposite, lanceolate, at first sessile, cordate, later shortly petiolate, up to 6 inches long and 1 inch wide. Normal leaves narrow lanceolate, 4–8 inches long, 5–9 lines wide, tapering to a point, not shining, of equal colour on either side; lateral veins not usually prominent, inclined at an angle of 30°-45° to the mid-rib, intramarginal vein somewhat looped and removed from the edge. Peduncles axillary 1–2 lines long, flowers sessile, in threes. Calyx tube under 2 lines long, 1½ lines wide; operculum conical, acute or slightly acuminate, about 1 line in length. Fruit conical or slightly conico-turbinate, rim rounded; valves strongly exerted; under 3 lines long and 2 lines in diameter.

Range.—Type specimen is from the eastern fall of the Main Dividing Range, at an elevation of about 4,000 feet, three miles south of the Big Badja Mountain. It has been

observed also from Mount Darragh, near Cathcart in the south, as far north as the Tallaganda State Forest, at high elevations.

Affinity.—This species is closest in external morphology to *E. viminalis*, which occurs in the same district. The fruits are, however, consistently smaller and not pedicellate, as usually obtains in that species, nor are they hemispherical. The operculum is short and broad, conical, acute or slightly acuminate, not obtuse, egg-shaped, as in *E. viminalis*. Other differences will be noted under field and anatomical characters.

Field Characters.—It differs from *E. viminalis* in several very important field characters, and cannot readily be confused with that species, with which it is often in association. *E. viminalis*, whether smooth barked from the ground up, or rough barked at the butt, is white above, whereas the rough bark of the proposed species more closely resembles that of *E. goniocalyx;* the upper smooth portion is greenish in colour, approaching that of *E. stellulata.* Moreover, *E. viminalis* in the same locality possesses a typical "candle-bark," the decorticated portion hanging in long ribbons, which does not occur, as far as our observation has gone, in this species. The bark possesses a very marked "piney" odour when cut, due to the very large development of oil glands.

The leaves are always narrow (mallee-like), enabling this species to be picked out readily from *E. viminalis,* which, growing in association, possesses broader leaves which are a much brighter green in colour. This character alone is sufficient to separate the trees when seen together in the field. These bark and leaf characters are constant throughout the entire range. Another interesting point is that, to our knowledge, manna has never been found

beneath this tree, in marked contrast to *E. viminalis,* the Manna Gum of the Monaro.

Anatomical Details.

Leaves.—Average thickness 375μ. Palisade mesophyll practically extends across leaf section (Plate IX., fig. 1), spongy mesophyll being reduced to a minimum. Leaf is isobilateral, stomata being developed equally on either surface. Oil glands measure up to 270μ in diameter; average number per sq. mm. of leaf surface, 7.4. Abnormal leaf anatomy similar to above, except that stomata are somewhat more numerous on the abaxial surface.

Bark.—The general anatomical structure of the secondary phloem presents nothing new. The fibre zones are small and numerous, averaging in section 300μ × 20μ in the specimens examined. (*E. viminalis* 450μ × 150μ.) This is in all probability, however, a variable factor, and there is not sufficient evidence on Eucalypt bark anatomy to say whether it is of any taxonomic value. One very striking feature, however, is the very large development of oil glands. These, in the specimens examined (Plate IX., fig. 2), are arranged in almost the same manner as in *E. Smithii**, i.e., in groups of large oil glands visible to the naked eye. They occur in loose parenchymatous tissue formed by the irregular widening of the medullary rays. No evidence has been found of oil glands scattered throughout the secondary phloem, as obtains in the majority of Eucalypts, including *E. viminalis,* in which they occur. In the proposed species, oil glands measuring up to the very large size of 250μ have been observed, the mean being 150μ, whereas in *E. viminalis* (Welch *l.c.*) the glands are comparatively small. The phellogen is developed at intervals in the secondary

---

*Welch, "The Occurrence of Oil Glands in the Barks of Certain Eucalypts". Proc. Linn. Soc. N.S.W. 1922, pp. 428-438.

phloem, producing a succession of absciss phelloids in the periderm.

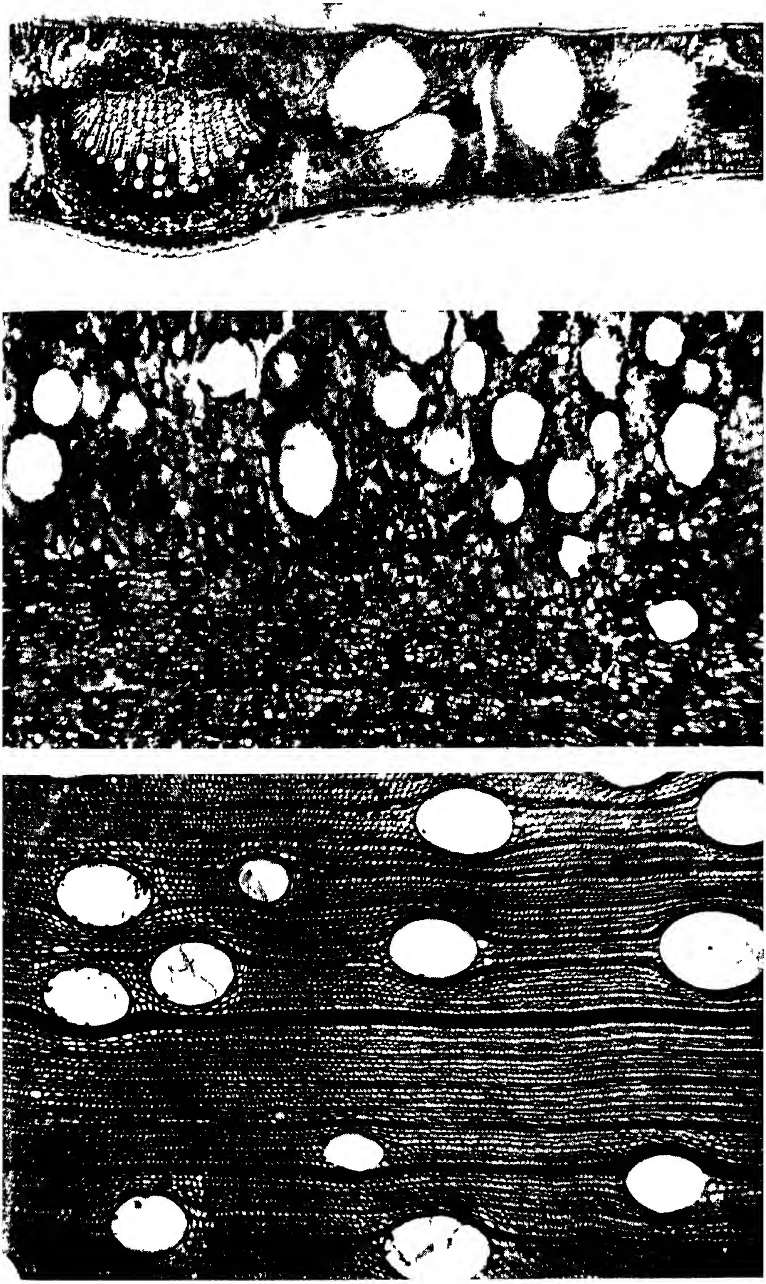
Wood.—Diffuse porous, pores usually single, oval with the longer axis directed radially, 60μ — 300μ in diameter, walls 3μ — 4μ in thickness, pits on vessel walls numerous, small, bordered, or large and simple in contact with the ray cells, end perforation simple, 4–9 per sq. mm. Tyloses often present. Tracheids 450μ to 1100μ in length, 15μ — 26μ in width, irregular in shape, usually with blunt ends, bordered pits numerous. Fibre-tracheids 675μ — 900μ in length, about 18μ in width, with fairly numerous bordered pits, showing undoubted transition to wood fibres, which are usually longer, thicker walled and with fewer pits, which are not simple. Length of fibres from 500μ to 1400μ. Wood parenchyma sparse, paratracheal or scattered, cells often measuring up to 450μ in length. Medullary rays, uniseriate or commonly multiseriate, 3-18 cells high, often containing small globules of an oily nature.

The timber is pale reddish in colour (heart-wood), sapwood wide, light-coloured, with distinct growth rings, and is characterised by small black stains, which are usually under $\frac{1}{4}$ inch in vertical height, and $\frac{1}{8}$ inch in tangential width, but extending radially for several inches.* Branched septate fungal hyphae have been found in the discoloured areas, and the wood parenchyma, medullary rays and also some of the prosenchymatous cells possessed darkened contents. The fungus has not been identified. Largely owing to the presence of this black stain, the timber has so far found little use, especially since large supplies of the Brown Barrel, *E. fastigata,* are usually available in the same district. The wood is of moderate weight for a

* Similar stains have been found in the woods of *E. Sieberiana* and *E. nitens,* but are not usual.

T. Gillogley, del ad. nat.

Eucalyptus Badjensis (de Beuzeville et Welch). × ½



hardwood, and should be suitable for all building purposes, though its durability has yet to be proved. From the specimens seen it is probable that careful seasoning will be necessary, since there was evidence of "wash-boarding," probably due to cell collapse. This defect is, however, common in many of the lighter weight Eucalypt woods.

In conclusion we wish to express our thanks to Mr. R. T. Baker for his kindness in looking over the material, and his many useful suggestions, and to Mr. G. Hooper, F.T.C., for enabling one of the authors to visit the locality and for his assistance in other ways.

Explanation of Plates.

Plate VIII.

E. Badjensis, sp. nov. × ½

Plate IX.

Fig. 1.—Transverse section of portion of leaf, *E. Badjensis,* × 60.

Fig. 2.—Transverse section of bark, showing numerous oil glands, *E. Badjensis,* × 60.

Fig. 3.—Transverse section of wood, *E. Badjensis,* × 60.

THE ESSENTIAL OILS OF MELALEUCA ERUBESCENS (OTTO), AND M. HYPERICIFOLIA (SMITH).

By A. R. Penfold, F.A.C.I., F.C.S.

Economic Chemist, Technological Museum, Sydney.

(Read before the Royal Society of N.S. Wales, October 1, 1924).

Melaleuca erubescens (Otto.)

The botany of this species is referred to in "Flora Australiensis," Vol. III., page 159, but has been more fully treated and its wide distribution dealt with by Mr. E. Cheel of the National Herbarium, Sydney, in the present volume of this Society's proceedings, when re-establishing this Myrtaceous plant to specific rank. It is a short, heath-like shrub, with small green leaves and reddish purple flowers, and is found very widely distributed, especially in New South Wales. It occurs usually in swampy situations, and quite close to Sydney at such places as Cabramatta and Guildford. Leaves and terminal branchlets for examination of the essential oil were obtained from Guildford, 16 miles south of Sydney, and Gwabegar, 374 miles west of Sydney.

The Essential Oil.

The essential oils were of a pale lemon colour with a pleasant odoùr of cineol modified by terpenes, and closely resembled in general characters an ordinary grade cineol Eucalyptus oil. Altogether 275lbs. of leaves and terminal branchlets, cut as for commercial purposes, yielded on steam distillation an average yield of oil of 0.44%, varying from 0.33% to 0.62%. The principal constituents, so far identified, were found to be cineol (43-56%), *a*-pinene, limonene, dipentene, *a*-terpineol, sesquiterpene and small quantity of a phenol.

Experimental.

Two hundred and seventy-five lbs. weight of leaves and terminal branchlets from the places mentioned, yielded on distillation with steam, crude oils, possessing the chemical and physical characters shown in table:—

Date	Locality	Weight of Leaves	Yield of Oil	Specific Gravity $\frac{15}{15}$° C.	Optical Rotation
22/8/1922	Guildford near Sydney	118 lbs.	0·33%	0·9030	+5·25°
7/2/1923	ditto	95 lbs.	0·62%	0·9085	+4·45°
19/10/1923	Gwabegar, N.S. Wales	62 lbs.	0·37%	0·9103	−0·65°

Refractive Index 20° C	Solubility in 70% alcohol (by weight)	Ester No. 1½ hours, hot	Ester No. 1½ hours hot sap after acetylation	Cineol in crude oil. (Phos acid method)
1·4676	insoluble in 10 vols.	1·72	36·83	45%
1·4656	soluble in 1·7 vols	1·77	30·36	56%
1·4671	soluble in 2 vols.	13·46	52·94	43%

On distillation, the crude oils behaved as follows:—

22/8/1922.—100 c.c. at 10 mm.:—72% at 60-65°C., and 18% at 65-78°C.

7/2/1923.—100 c.c. at 10 mm.:—69% at 60-65°C., and 18% at 65-78°C.

19/10/1923.—100 c.c. at 10 mm.:—85% below 70°C., 2½% at 70-92°C., 3½% at 92-108°C., and 8% at 110-127°C.

Determination of Terpenes.—On removal of cineol from the fractions of the first two consignments distilling below 65°C., at 10 mm. by means of 50% resorcin solution, the resultant residual oil gave the following results on distillation at 768 mm.:—

	Sp. Gr. $\frac{15}{15}$° C.	Opt. Rot.	Ref. Index 20° C
50% distilling at 162 – 166° C,	0·8531	+13·1°	1·4690
50% ditto 166 – 169° C,	0·8523	+12·2°	1·4722

These figures point to the above fractions consisting of a mixture of α-pinene with limonene and dipentene, especially as the first fraction on redistillation yielded a good proportion boiling below 160°C., which on treatment with amyl nitrite and acetic-hydrochloric acid yielded a nitrosochloride, which melted and decomposed at 109°C. The second fraction was dissolved in glacial acetic acid and bromine added, and gave an excellent yield of tetrabromide, which on re-crystallisation from ethyl acetate melted at 124–125°C., thus showing the presence of dipentene with a small quantity of limonene.

Determination of Cineol.—The percentage of cineol present in all three crude oils was determined by the phosphoric acid method. The crude cineol regenerated from the resorcin solution used in its separation from the terpenes possessed the following characters:—Boiling Point, 176–177°C., at 764 mm. sp. gr. 15/15°C., 0.9283, optical rotation—0.3°, refractive index, 20°C., 1.4589. Confirmation was obtained by the preparation of the iodol compound which melted at 112–113°C.

Determination of Terpineol.—The higher boiling fractions of the first two lots of oil were united and fractionally distilled at 10 mm. In this way 6 c.c. of liquid were obtained, possessing the following characters:—B. Pt., 100–110°C. at 10 mm. sp. gr., 15/15°C., 0.9289, optical rotation +6.9° and refractive index, 20°C., 1.4848. It readily yielded a phenylurethane of melting point 111–112°C.

From 100 c.c. of the Gwabegar consignment of oil was obtained 3.5 c.c. of oil, distilling at 93-108°C. at 10 mm., with a sp. gr. 15/15°C. of 0.9356, optical rotation—6.8° and refractive index 20°C., 1.4805. This sample gave a splendid yield of phenylurethane melting at 112–113°C.

Determination of sesquiterpene.—The very small residues resulting from the repeated fractional distillation of

the crude oils were repeatedly redistilled when a few c.c. only were obtained, boiling at 120-136°C., at 10 mm., possessing the following constants:—Sp. gr., 15/15°C., 0.9403, optical rotation, + 4° and refractive index, 20°C., 1.4960. The quantity was too small for purification, but the usual colour reactions obtained with bromine vapour and sulphuric acid in acetic anhydride characteristic of sesquiterpenes from the Myrtaceae were sufficient to denote the presence of such a constituent.

Phenol.—A small quantity of a phenolic body was present to the extent of 0.3%, which gave a brown colouration with ferric chloride in alcoholic solution.

My best thanks are due to Mr. Gordon Burrow, District Forester, Narrabri, N.S.W., for his usual kindness in collecting and forwarding the consignment of leaves from Gwabegar.

MELALEUCA HYPERICIFOLIA (Smith).

The botany of this interesting Myrtaceous plant is fully described in "Flora Australiensis," Volume III., page 131. It is a tall glabrous bushy shrub with handsome foliage and very beautiful crimson "bottle brush" flowers. Although it is stated by botanists to occur in sandy soil close to the sea on the East Coast of Australia, principally the South Coast of New South Wales, the author believes it attains a more luxuriant form when found in the moist ledges and clefts of the Great Dividing Range. Evidence of this was obtained in the course of examination of its essential oil from material collected at Stanwell Park, South Coast, 35 miles from Sydney, the mountain ranges, 16 miles back from Moruya (South Coast, N.S.W.), and Wentworth Falls, Blue Mountains, N.S.W. The trees at the first named place were of good age and were growing in clayey soil at the foot of a hill adjacent to the sandy beach of the Pacific Ocean, where

they were much exposed to the ocean breezes and strong southerly winds. Consequently, many of the plants showed pronouncedly the effect of the prevailing winds, as instead of being tall upright bushes they were bent almost at right angles to the trunk, and gave one the impression that they had adapted themselves to an uncongenial environment. Mr. R. McDiarmid, of Moruya, in forwarding a supply of the leaves and terminal branchlets in 1922, wrote, "This bush seems to grow out of bare rock in running water at a very high elevation, almost on top of the Dividing Range."

The plants at Wentworth Falls were comparatively young, and were growing in soil rich in humus plentifully supplied with moisture in the part known as the Valley of the Waters, right at the foot of the Falls. Very interesting results were, therefore, obtained when material from the three localities mentioned were subjected to steam distillation and the essential oils thereby obtained examined. The Stanwell Park consignment yielded only 0.16% of oil containing 64% cineol against Moruya material, 1.66% of oil containing 84% cineol and Wentworth Falls, 1.13% of oil with 86% cineol. These observations offer additional evidence that many Myrtaceous essential oil yielding plants yield both variable quantities of oil and principal constituent according to their ecological conditions, a considerable increase often resulting in both, if the plant be grown under especially favourable conditions.

The Essential Oil.

The essential oils obtained from the three consignments varied from a pale to a deep yellow colour, with a pronounced odour of cineol, and closely resembled in general characters a high cineol content Eucalyptus oil. The principal constituents, so far identified, were found to be cineol

(64-86%), dipentene, limonene, a-pinene, sesquiterpene and a very small quantity of a phenol.

In this connection, Messrs. Schimmel and Co., of Miltitz, near Leipzig, in their Semi-Annual Report of October, 1914/April 1915, page 53, refer to a sample of oil distilled from this *Melaleuca* by the Biological Agricultural Institute of Amani (German East Africa), submitted to them for valuation. They state that it was of a pale green colour and in odour and constants showed a certain similarity to *E. globulus* oil. It possessed a specific gravity, 15/15°C. of 0.9145, optical rotation + 0°.18′, refractive index, 20°C., 1.4627, and contained 72% cineol by the resorcinol method.

Experimental.

One hundred and ninety-five and a half lbs. weight of leaves and terminal branchlets, cut as for commercial distillation, yielded on distillation with steam, crude oils, possessing the chemical and physical characters shown in table:—

Date.	Locality	Weight of Leaves	Yield of Oil	Specific Gravity $\frac{15}{15}$°C
8/9/1922	Stanwell Park, N.S Wales.	119 lbs.	0·16%	0·9161
13/9/1922	Moruya. N S.W	46 lbs.	1 66%	0·9230
14/6/1924	Wentworth Falls N S. Wales	30½ lbs.	1·13%	0·9239

Optical Rotation	Refractive Index, 20°C	Solubility in 70% alcohol (by weight)	Ester No hot 1½ hrs.	Ester No. hot, 1½ hours after acetylation	Cineol (Phos acid method)
+ 2·5°	1·4650	sol., 1·1 vols.	6·84	23·05	64%
+ 1·55°	1·4592	,, 1·0 ,,	6·46	21·42	84%
+ 1·4°	1·4598	,, 1 0 ,,	8·92	18·2	86%

On distillation, the crude oils behaved as follows:—

8/9/1922.—55 c.c. distilled at 765 mm.:—2½c.c. below 170°C., 35 c.c. at 170-176°C., 12½ c.c. at 177-180°C., and 5½ c.c. residue.

13/9/1922.—100 c.c. distilled at 10 mm. gave 83% distilling at 50-60°C., and 12% at 60-63°C.

Determination of Terpenes.—On removal of cineol from the fractions boiling below 180°C. at 765 mm., by means of 50% resorcin solution, the resultant residual oil gave the following results on distillation at 762 mm.:—B. Pt. 160-170°C., sp. gr. 15/15°C., 0.8616, optical rotation + 7.15°, and refractive index, 20°C., 1.4709. On re-distillation a few c.c. were obtained boiling below 160°C., which on treatment as described under *M. erubescens* readily yielded a nitrosochloride, which melted with decomposition at 109°C. The higher boiling fraction distilling between 165-170°C., when dissolved in glacial acetic acid and bromine added, gave an excellent yield of tetrabromide, which on re-crystallisation from ethyl acetate melted at 122-123°C. These results point to the presence of α-pinene, dipentene and limonene.

Determination of Cineol.—The percentage of cineol in all three crude oils was determined by the phosphoric acid method. The crude cineol regenerated both from the phosphoric acid and resorcin combinations gave similar chemical and physical constants to those described under *M. erubescens.* The iodol compound prepared therefrom melted at 112-113°C.

Other Constituents.—The very small quantity of high boiling residues (above 180°C.), were mixed and a careful search made for terpineol without result. The quantity available was altogether too small for thorough examination, but the usual colour reactions with bromine vapour and sulphuric acid in acetic anhydride solution for sesquiterpene were readily obtained. The crude oils were found to contain only about 0.1% of phenolic constituents giving a brown colour with ferric chloride in alcoholic solution. A small quantity of paraffin melting at 60°C. was also obtained.

My thanks are due to Mr. R. McDiarmid of Moruya, N.S.W., for his kindness in forwarding an excellent supply of leaves, and to Mr. F. R. Morrison, A.T.C., A.A.C.I., Assistant Economic Chemist, for much assistance in these investigations.

NOTES ON MELALEUCA, WITH DESCRIPTIONS OF TWO NEW SPECIES AND A NEW VARIETY.

By Edwin Cheel.

(Read before the Royal Society of N.S. Wales, October 1, 1924).

The present paper is a continuation of my researches in connection with the various species of the genus *Melaleuca* (see 6, 7 and 8), and includes notes on five species which have previously been regarded as synonyms or varieties of other species, and descriptions of two species, and a variety, which have apparently not previously been described.

Melaleuca erubescens Otto (9).
(*M. diosmifolia* Dum. Cours. in DC. (9)).

The description of this species appears to have been drawn up from plants cultivated in the Botanic Gardens, Berlin. Specimens from Parramatta, collected by Rev. W. Woolls, were examined by Bentham (3), who regarded it as a variety of *M. ericifolia* Sm. (23) (24), with the following brief characters:—"Flowers red, stamens usually more numerous." Then we have *M. armillaris* Sm. var. (?) *tenuifolia* Benth. (3):—"Leaves semi-terete, very narrow, under ½ in. long. Flowers smaller. *M. cylindrica* R. Br., Herb. Duck (Dunk in error) River, R. Brown, perhaps a distinct species." Baker (2) records it from Shuttleton, Nymagee, as a distinct species, but makes no reference to it being regarded as a variety of *M. ericifolia,* and as a variety of *M. armillaris* by Bentham. The *M. cylindrica* of Brown seems to have been regarded as a native of South Australia, as we find it listed by Tate (25), but as no specimens from South Australian localities are

represented in any herbaria, it has been decided by Black (4) to recommend the omission of *M. cylindrica* from the South Australian Flora.

From an examination of the large series of specimens in the National Herbarium, Sydney, there can be no doubt that *M. erubescens* is distinct from both *M. ericifolia* and *M. armillaris,* as the leaves are cylindrical and not sub-terete or narrow-linear, as in those species. The stamens are of a lilac or rose-pink colour, whilst those of *M. ericifolia* and *M. armillaris* and varieties are constantly white or creamy-yellow. The habitat of the two latter species seems to be confined to the coastal districts, chiefly in the peaty-bogs in sandstone areas, whilst *M. erubescens* has a very extensive range, extending from the Wianamatta Shale series from Lidcombe to Hurstville, and to Cabramatta and Lane Cove in the Port Jackson district, it occurs also in the Pilliga Scrub District, Temora, Warialda and near Cobborah.

Melaleuca Gunniana Schauer (21).

(Swamp Tea-Tree).

The type specimen of this species was collected on the River Nile, Tasmania, by Stuart.

Schauer's description is in Latin, which may be translated as follows:—

"Glabrous glaucescent; leaves alternate, crowded, linear-lanceolate, somewhat thick and more or less recurved, shortly petiolate, pointed; flowering-spike ovoid, infra-terminal, the flowers crowded; calyx-tube cup-shaped, glabrous; calyx-lobes herbaceous, ovate, somewhat obtuse; staminal-bundles with about 5-7 stamens about 15 mm. long; petals about as long as the stamens."

It is included under *M. ericifolia* Sm., as a synonym by Hooker (11), Bentham (3), and Rodway (20).

In the National Herbarium, Sydney, there are specimens from Tasmania collected by W. H. Archer and Miss Grovin, without any specific locality being mentioned, and from Esk, Flinders Island and Georgetown, collected by R. C. Gunn in September, 1844, under Nos. 18, 405 and 1069. There are also specimens from Kent's Group (Allen) ex. Herb. S. G. Hannaford; Deloraine, J. H. Maiden; Mount Arthur (J. B. Cleland); Bass Straits, Bynoe, and a photo. by Keith Kennedy of a tree at Penguin on the N.W. Coast.

Although I have not seen the original specimens of *M. heliophila,* F.v.M.(18), I am of opinion that this is synonymous with *M. Gunniana.* The specimens on which this species was founded were collected on the Yarra, Victoria, and we have specimens in the National Herbarium, Sydney, from Upper Yarra, C. Walter; Port Phillip, G. Luehmann; Mordiallac, C. Walter; Metung, J. H. Maiden and Narree Warren, J. Staer, all of which are distinct from *M. ericifolia* Sm., with which they have been previously confused.

In general appearance, herbarium specimens resemble those of *M. viminea* Lindl. more closely than those of *M. ericifolia* Sm. It has also been confused with *M. pustulata* Hook, but the leaves of the latter are obtuse and more cylindrical, and the flowers arranged in terminal leafy-heads which puts the species in another section (Pauciflorae).

MELALEUCA TERNIFOLIA F.v.M.(18).

The type specimens on which the above species was founded were collected in the Argyle county by Mueller, and described in Latin, which may be translated as follows:—

"Branches slender, somewhat pale in colour, striate; leaves ternate, about 3 lines long, shortly petiolate, more

or less recurved and spreading, narrow-linear acute or sub-terete and more or less compressed with obscure nerves but dotted with oil-glands; spike terminal, petals reddish, staminal bundles with 8 stamens."

This species is mentioned by Bentham(3), who states that it was "not sufficiently described to be recognisable, but probably belongs to some of the above species." There are specimens in the National Herbarium, Sydney, which clearly belong to this species, from Shoalhaven River, collected by W. Bauerlen in December, 1898, and at Reedy Creek and Tarago, near Braidwood, by R. H. Cambage (No. 2013), in October, 1908.

The above mentioned specimens have been erroneously determined as *M. ericifolia*, but may be separated by the distinctly verticillate or ternate leaves, which are also shorter and more obtuse, also studded with more prominent oil-glands than those of *M. ericifolia.* The sepals are more ovate, larger and herbaceous, and the bracts exceed the length of the calyx-tube and are distinctly convolute-pointed.

MELALEUCA HOWEANA, *sp. nov.*

Plants of a shrubby habit or small trees. Leaves fusiform-cylindrical, minutely but distinctly petiolate, nerves or veins obscure. Floral characters similar to those of *M. ericifolia,* but sepals smaller and rachis hispid. Calyx-tube more or less angular, lobes persistent, fruits larger than those of *M. ericifolia.*

Habitat:—Lord Howe Island, E. King and J. H. Maiden, January, 1898; J. L. Boorman, May, 1920.

Although this species has been included by Bentham(3), and Maiden(14), under *M. ericifolia,* it more closely approaches *M. Gunniana* Schauer and *M. pustulata* Hook(11). Maiden, *l.c.,* remarks "The settlers have an

idea that this is identical with the New Zealand shrub, and call it the 'Kilmauk' or 'Kilmogue' of New Zealand, but the plant does not occur in that colony. The leaves are coarser, shorter and more rigid than they usually are on the mainland. It no longer appears to be used medicinally or otherwise by the settlers."

Mr. Boorman remarks that it is "fairly common, growing in wind-swept places on and between crevices of rocks, with a full exposure to winds and ocean spray, at the north hills near the 'Lookout.' "

MELALEUCA SQUAMEA Labill.

The original specimens described in Labillardiere's work(12), were collected in Tasmania.* Bentham(3), gives Huon River and Port Dalrymple as Tasmanian localities.

In addition to the localities recorded by Bentham, there are specimens in the National Herbarium, Sydney, as follows:—Recherche Bay, foot of Streleski Mountain, Circular Head, Lake St. Clair; summit of Mount William, Victoria, C. Wilhelmi; Geeveston and Hartz Mountains, Tasmania, A. H. S. Lucas, January, 1901; Waratah (Mount Bischoff), Tasmania, R. H. Cambage (No. 2565), January, 1911; Scottsdale, Tasmania, J. H. Maiden, January, 1902.

var. *glabra, var. nov.*

Similar to the type, but the whole plant almost glabrous.

Specimens from the following localities with calyx-tube almost glabrous, and which are regarded as *M. squamea var. glabra,* have been received from the following localities:—Coogee, H. Deane; Botany to La Perouse, E. Betche, J. H. Camfield and E. Cheel, the latter collected in flower, May, 1898; Kurnell, E. Cheel and J. L. Boorman; Diamond Bay and Bondi, J. H. Maiden; Cronulla, E.

* See also (10).

Cheel, September, 1903; Bulli, J. H. Maiden, September, 1891, R. H. Cambage (No. 1041), September, 1903; Woodburn, Clarence River, W. Bauerlen (No. 1583), August, 1895; Wentworth Falls, H. Deane; Blackheath, R. H. Cambage (No. 1202).

I have not seen the specimens from near Appin, N.S.W., Grampians and on the Glenelg, Victoria, nor from Mount Gambier, at the S.E. extremity of South Australia, mentioned by Bentham, so cannot say if these belong to the type species or the var. *glabra.*

MELALEUCA CAPITATA, *sp. nov.*

Plants usually rather densely branched, of a shrubby habit, 3 to 6 feet high, the young shoots villous. Leaves alternate, thick, more or less subulate-acute, 2½ cm. long, 2 mm. wide, 3-nerved, the central nerve raised on each side of the leaf and forming a very distinct but extremely narrow channel through the cuticle forming parallel ridges on either side of the midvein; oil glands not visible owing to the thickness of the leaf, but seen as thinly scattered raised tubercles in the dry herbarium specimens. Inflorescence terminal, the flowers densely packed in subglobose heads about ¾ to 1 inch in diameter. Bracts slightly longer than the flowers, acute, hispid on the outside, glabrous on the inside. Calyx-tube hispid, with greyish côloured hairs, the lobes also hispid, rounded, persistent, one-third as long as the calyx-tube. Petals white, about 4 mm. long, or slightly longer than the calyx-lobes. Stamens palė yellow, 4-6 mm. long, shortly clawed with from 14 to 18 stamens. Style simple, about as long as the stamens. Fruits about 6 mm. diameter, the rim rather thin, slightly contracted at the orifice, which is truncate, valves 3, rather deeply sunk in the capsule, which enlarges slightly with age.

The affinities of this species are with *M. squamea* Labill, but the coarser branches and branchlets, larger leaves, which are not concave as in *M. squamea,* and larger flowers and flower-heads, which are more rounded and flowers yellow, easily separate it from *M. squamea.* The calyx-tube of the New South Wales plants which have been separated as var. *glabra* of *M. squamea* are almost glabrous, and the filaments are of a reddish colour.

Distribution: It is usually found along the water-courses as follows:—Jervis Bay, J. H. Maiden, July, 1899; R. H. Cambage (No. 4258), December, 1916; Table Mountain, Milton, R. H. Cambage (No. 4053), December, 1913; Nowra to Nerriga, J. L. Boorman, February, 1910; Currockbilly Mountain, near Braidwood, J. L. Boorman, March, 1899 and September and December, 1915. In general appearance *M. capitata* somewhat resembles *Callistemon pityoides* F.v.M. or *C. Sieberi* DC., especially the leaves, and has been mixed up in herbaria with this species.

MELALEUCA ALTERNIFOLIA, *sp. nov.*

(Syn. *M. linariifolia* var. *alternifolia,* Maiden and Betche (15 and 16).)

This was described by Messrs. Maiden and Betche as a variety of *M. linariifolia.* The type of the variety was described from specimens collected at Coff's Harbour to Grafton in the following words:—"Leaves alternate, much narrower and usually shorter than the type. The whole plant is glabrous, and the flowers are loosely scattered in an interrupted spike." This form is rather common in the northern coast districts, and seems to extend from Stroud to the Richmond River.

In September, 1916, I had an opportunity of examining this species in the field at Copmanhurst, where it is fairly

abundant, and although it has a superficial resemblance to *M. linariifolia,* it is evidently distinct when more closely examined. For instance, the habit of the tree is more compact and not nearly so tall as in *M. linariifolia.* Besides, the latter species does not appear to exist in the same localities as the supposed variety *alternifolia.* It is interesting to note also that specimens from the neighbourhood of Copmanhurst collected in 1909 and 1910 by Mr. Boorman and Rev. H. M. R. Rupp (No. 16), were formerly labelled *M. parviflora.*

The following are additional localities to those given by Maiden and Betche:—Stockout Creek, Coledale Road, Copmanhurst, J. L. Boorman, Rev. H. M. R. Rupp and E. Cheel; Woodford Island, Clarence River, E. J. Hadley; Richmond River, J. Henderson, Casino, District Forester; Stroud, A. Rudder: Wallangarra and Stanthorpe, J. L. Boorman. The latter is in Queensland, and it would be of special interest to examine the Moreton Bay and Rockhampton specimens recorded for that State by Bentham (3), and Bailey (1), to see if they really belong to *M. alternifolia* rather than to *M. linariifolia* or *M. trichostachya.* See these proceedings (7), for a complete distribution of the two latter species.

Summary.

The following specimens, previously included as synonyms under *M. ericifolia,* are now raised to specific rank as:—

(1) *M. erubescens.* (3) *M. ternifolia.*
(2) *M. Gunniana.* (4) *M. Howeana, sp. nov.*

The following specimens are described as new:—

(1) *M. Howeana, sp. nov.* (2) *M. capitata, sp. nov.*

The following is regarded as a new variety:—

M. squamea var. glabra.

M. linariifolia var. *alternifolia* is now separated as a species distinct from *M. linariifolia.*

Bibliography.

(1) Bailey, F. M., Queensland Fl. II., p. 603, 1900.

(2) Baker, R. T., Proc. Linn. Soc. N.S.W., 1906, XXXI., p. 714.

(3) Bentham, G., Flora Australiensis, III., p. 155, 1866.

(4) Black, J. M., Trans. Roy. Soc. S.A., 1920, XLIV., p. 195.

(5) Brown, R., Hort. Kew (Ed. 2), p. 412, 1812.

(6) Cheel, E., "Notes on three species of *Melaleuca*," Trans. Roy. Soc. S.A., 1919, XLIII., p. 368.

(7) Cheel, E., "Notes on *Melaleuca linariifolia* Sm., and *M. trichostachya*," Roy. Soc. N.S.W., 1922, LVI., p. 78.

(8) Cheel, E., in Ewart's Flora N. Territory, 1917, Appendix ii., p. 290.

(9) DeCandolle, A. P., Prod. Syst. Nat. III., p. 214, 1828.

(10) Edward's Botanical Register, Pl. 477, 1820.

(11) Hooker, J., Flora Tasmania, II., p. 128, 1860.

(12) Labillardiere, J. J., Novæ Hollandiæ Plantarum, ii., p. 28, 1806.

(13) Link, Dr. H. F., Enum. Plant. Horti. Regi. Bot. Berol. II., p. 272, 1822.

(14) Maiden, J. H., Proc. Linn. Soc., N.S.W., 1898, XXIII., p. 129.

(15) Maiden, J. H., and Betche, E., Proc. Linn. Soc., N.S.W., 1904, XXIX., p. 742.

(16) Maiden, J. H., and Betche, E., Census of N.S.W. Plants, p. 155, 1916.

(17) Moore, C., and Betche, E., Handbook of the Flora of N.S.W., p. 197, 1893.

(18) Mueller, Baron F. von., in Miq. Ned. Kruid. Arch. IV., 119 and 123, 1856.

(19) Mueller, Baron F. von., Census of Australian Plants, p. 95, 1889.

(20) Rodway, L., The Tasmanian Flora, p. 54, 1903.

(21) Schauer, in Walp. Rep. II., p. 928, 1843.

(22) Schauer, Miq. Ned. Kruidk. Arch. IV., p. 119, No. 4., 1856.

(23) Smith, Sir J. E., Trans. Linn. Soc. Lond. 1797, iii, p. 276.

(24) Smith, Sir J. E., in Rees, XXIII., No. 10, 1819.

(25) Tate, R., Handb. Fl. Extratrop. Fl. S.A., p. 93, 1890.

ON THE STRATIGRAPHY OF THE BASAL PORTIONS OF THE PERMO-CARBONIFEROUS SYSTEM IN THE HUNTER RIVER DISTRICT.

By W. R. Browne, D.Sc.,
Assistant-Professor of Geology, University of Sydney,
and
W. S. Dun,
Palaeontologist to the Geological Survey of N.S.W., and Lecturer in Palaeontology, University of Sydney.

(Read before the Royal Society of New South Wales, Oct. 1, 1924.)

Introduction.

In mapping the Hunter River coal-measures, Professor Sir Edgeworth David* took as the basal member of the Permo-Carboniferous system a horizon of chocolate-coloured shales containing abundant glacially-striated pebbles: this horizon he called the Lochinvar shales, from the good exposures observed about a mile north of the village of that name.

Subsequently to his discovery, in 1914, of evidences of glaciation in the upper or freshwater division, now known as the Kuttung division, of the Carboniferous strata, Professor David appears to have altered his opinion as to the geological age of these Lochinvar shales, and in the paper written jointly by him and Mr. C. A. Süssmilch† they are, along with the overlying plant-bearing sandstones, grouped with the Kuttung strata, while the base of the Permo-Carboniferous is fixed at a horizon of conglomerate some 300 feet stratigraphically above the Lochinvar shales. It is also suggested in the same paper that

* Geol. Surv. N.S.W., Memoir No. 4.
† This Journal, Vol. LIII, 1919, p. 246.

the rocks previously grouped together as Lower Marine Permo-Carboniferous really consist of two subdivisions, the upper portion, down to the top of the *Eurydesma cordatum* conglomerate horizon, being Permian, the remainder, down to and including the "Brandon Conglomerate," being Uralian or Upper Carboniferous.

Apparently in consequence of the discovery of the evidence described below, Professor David, in the Guide Book to the Hunter River Excursion, published in connection with the Sydney meeting of the Pan-Pacific Scientific Congress in 1923, restored the Lochinvar shales to their original position as the basal beds of the Permo-Carboniferous system. It is considered that the evidence referred to above is of sufficient importance to warrant some description.

Field Notes.

A few years ago, while examining the geology of the Parish of Gosforth, north of West Maitland, one of the authors (W.R.B.), in company with Mr. (now Dr.) A. A. Pain, discovered marine fossils in the plant-bearing sandstone overlying the Lochinvar shales, showing that this formation, at all events, could not be included in the freshwater Kuttung series.

Accordingly, for mapping purposes, the Lochinvar shales were taken as a datum horizon, inasmuch as they gave, at all events, an approximate boundary between the freshwater Kuttung and the overlying marine strata. It was during the progress of this mapping, in the summer of 1923, that the discovery in the shales of marine fossils, identified by one of us (W.S.D.) as *Eurydesma hobartense*, was made.

The fossils in question were found in the bank of a creek just south of the north-west corner of portion 49, Parish of Gosforth, at a point where the creek-bank is

fairly steep owing to active erosion. As a matter of fact, at the time of a previous visit to the same spot, in 1915, no fossils were showing in the bank, and at the beginning of the present year only a few almost unrecognisable fragments of fossil shell were visible, so that the finding of a small number of fairly complete specimens in 1923 must be regarded as fortunate.

In the east or right bank of the creek there are Lochinvar shales weathering to the characteristic dark-red or claret colour. On top of these is a band, about three feet thick, of fairly hard, dark red mudstone, showing slight traces of bedding, and containing small rounded pebbles, but hardly in sufficient abundance to justify the term conglomerate; this is the band containing the fossils. It is overlain by about six or seven feet of finely-laminated shale, weathering to a greyish-brown colour, and breaking readily with the sub-conchoidal fracture so characteristic of certain types of shale and mudstone: on top of this is the sandstone containing the plant-remains.

It was found quite impossible to obtain reliable dips on either the mudstone or the underlying shales. Varying readings were obtained on both formations, probably as the result of faulting in the vicinity.

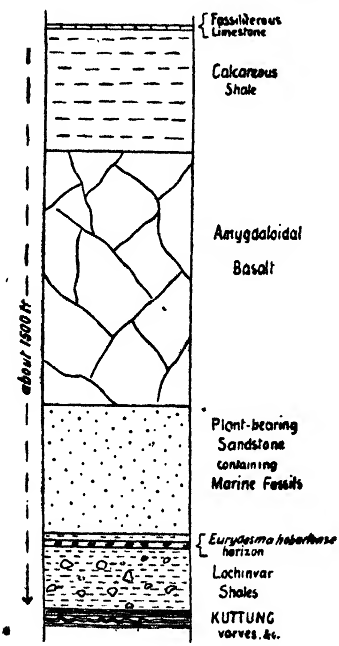
The Lochinvar shales, here as elsewhere in the district, are resting directly on top of Kuttung varves, but the actual plane of contact is obscured by creek alluvium. It would appear, then, that the junction between the freshwater Kuttung strata and the overlying marine beds is either at the base or at the top of the Lochinvar shales, whose thickness could not be exactly determined.

Whether these shales are to be regarded as of marine or of freshwater origin is uncertain. They are certainly very different from anything which has been observed in the Kuttung formation, as regards both the lithology of

the shales themselves and the nature and distribution of the pebbles with which they are often fairly thickly studded. These latter are usually well-rounded and fairly regularly distributed through the matrix, but only very locally are they so thickly aggregated as to form a conglomerate. They include many striated stones: indeed, these are more common in the Lochinvar shales than in any of the Kuttung fluvio-glacial conglomerates examined. The pebbles differ markedly, too, from those of the Kuttung conglomerates in lithological characters. Among the latter, granites and aplites form by far the most common and conspicuous types, with quartz-porphyries predominating in some of the upper horizons. This rule has been found to hold through a vertical range of about 5000 feet of strata. In the Lochinvar shales, on the other hand, the types mentioned are almost entirely lacking, their place being taken by diorites, gabbros and porphyrites or andesites, types which have not hitherto been noted in the Kuttung conglomerates. This change is most striking and must surely be significant, although its interpretation is a matter of some difficulty. It does seem reasonable, however, to suppose that these pebbles, which have evidently come from a glaciated region, have been derived from a terrain very different from that which supplied the material for the Kuttung fluvio-glacial conglomerates. An entirely new source of supply would appear to have been made available at the time of the deposition of the Lochinvar shales, and, as the Kuttung glaciers had apparently been bringing down the same sort of material for a very long time, and presumably from the same direction, one may surmise that the new and lithologically different material was borne to its present position by floating ice. In other words, the Lochinvar shale is perhaps to be regarded as a marine deposit, and in that respect comparable with the Upper Marine glacial horizon named by Professor

David the Muree rock. If this interpretation is correct, the top of the Kuttung sequence is to be placed immediately below the Lochinvar shales, as was originally done by Professor David.

As stated above, some years ago marine fossils were discovered in the plant-bearing sandstone outcropping in the parish of Gosforth. This formation, which is referred to in Professor David's memoir, immediately overlies, in the Gosforth district, the shales which succeed the *Eurydesma hobartense* beds, and forms a low ridge running parallel to and about 400 yards west of the Maitland road just south of the village of Gosforth. It has a tuffaceous appearance when fresh, and is in some places massive and in others rather flaggy. The lower parts contain indeterminate impressions of plant stems, and it was from the upper portions, which are in places pebbly, that the marine fossils were obtained which are described below.



Resting on these sandstones is a flow of basalt, amygdaloidal in places, and this appears to be overlain by calcareous shales, interbedded with which in a couple of places thin beds of fossiliferous limestone have been noted. The sequence is shown in the accompanying columnar section, which must be regarded as only very roughly quantitative, exact measurements being difficult. In the year 1917, one of the limestone outcrops, in portion 7, parish

of Gosforth, in a creek about 300 yards in a direction S. 35°E. from Mr. A. McDonald's house, from a face about three feet square yielded, thanks to the energy of a party of enthusiastic students, a number of forms which were first listed in the paper by Mr. Süssmilch and Professor David referred to above: this list is reproduced below.

Owing to the poor outcrops and the absence of reliable dips, it is impossible to give any very accurate estimate of thicknesses, but it would appear that the limestone horizon is possibly as much as 1500 feet up in the Lower Marine sequence, and not merely a few feet above the top Kuttung strata, as Süssmilch and David appear to have thought.*

The question of a possible unconformity between the Lochinvar shales and the underlying Kuttung rocks has been frequently discussed. A fairly close examination of the junction in the country north-north-east and north-west of Lochinvar would show that there is no warrant for affirming or denying the existence of such an unconformity. Dips quite as low as any recorded for the Lochinvar shales have been found in the underlying Kuttung rocks, and it is a common experience to find, in tracing a section through Kuttung strata, that the dip gradually diminishes in amount towards the top of the series, eventually approximating to that of the overlying Lochinvar shales. The presence of much minor faulting, too, vitiates the importance of any discordance in dips between beds separated by even a small interval, and the dips on the varve-beds are generally extremely unreliable. But in any case the presence or absence of angular unconformity is surely a matter of little stratigraphical moment, seeing that there is evidence of a change from freshwater to

* *loc. cit.* p. 301.

marine conditions and a very marked life-break in passing upwards from the Kuttung to the Permo-Carboniferous strata.

In no case, moreover, has any observed discrepancy of dip amounted to more than a few degrees, so that it may be safely assumed that no violent tectonic movements affected the Carboniferous strata, in this part of the State at all events, during the interval between the Kuttung and Permo-Carboniferous sedimentations.

Palaeontological Notes.

(a) *The Limestone Fauna.*

The list of fossils determined by one of us (W.S.D.) and referred to by Süssmilch and David, is as follows:—

Crinoid stems and ossicles, *Fenestella internata, F. fossula, F.* sp., *Seminula* sp. nov., *Martiniopsis subradiata, Spirifera* aff., *tasmaniensis* (a small type, probably transitional), *Deltopecten limaeformis, Aviculopecten englehardti, A. tenuicollis, A. mitchelli, Chaenomya* sp., *Conocardium* sp. nov., *Mœonia* sp. nov., *Orthoceras* sp.

This collection is unfortunately not available for further examination and for comparison with the specimens from the other horizons.

The Fenestellids have a range through both the Lower and the Upper Marine Series, the Spirifer is of the same type as that referred to below, and the Pectens are most definitely Permo-Carboniferous in type, mainly Lower Marine. A departure from a normal Permo-Carboniferous facies is afforded by the specimen probably referable to *Seminula.* A possible relationship with the Burindi fauna is evidenced by this latter and by the *Spirifera,* which may be regarded as a distinctly transitional type. In all other respects the fauna may be looked upon as definitely Permo-Carboniferous.

(b) *The Faüna of the Plant-bearing Sandstone.*

A few specimens of buff-coloured fine-grained sandstone, from portion 49, parish of Gosforth, show impressions and internal casts, somewhat compressed and distorted.

The commonest of these is a small *Spirifera* of the *striati* group, with well-developed, though thin, dental plates. The ornamentation is not that of the *S. tasmaniensis* so abundant in the Upper Marine Series, but is similar to that of smaller types occurring in the Lower Marine of Pokolbin. So far as can be seen from the casts, the median sinus of the pedicle valve contains from five to six folds, with about seven primary folds and secondary intermediate folds, extending for about two-thirds of the interspace.

This species, which is unnamed at present, cannot be directly compared with any of the Burindi species; nor, so far as is at present known, does it occur in the Permo-Carboniferous Upper Marine, being essentially of Lower Marine age. It is a different form from that recorded from the limestones.

Associated with the spirifer is the internal cast of a *Dielasma*, which conforms neither to the *sacculus* nor to the *cymbaeformis* type. The specimen is too imperfect to admit of any definite statement.

Impressions and casts of *Platyschisma* are similar to those occurring at higher horizons.

From the same sandstone formation at Gosforth a specimen of *Conularia* was collected by Mr. H. G. Raggatt, which appears to be the species figured by Laseron* as "cf. *laevigata,* Morris," and which "probably comes from the Lower Marine sandstone in the vicinity of Cessnock" (*loc. cit.*, p. 248). This is not Morris's *C. levigata*,† differ-

* This Journal, 1911, Vol. XLV, p. 247, pl. 11.

† Strzelecki's Phys. Descript N.S.W. & V.D. Land, pl. 18, figs. *a* and *b*.

ing from it in the markedly less inclination of the sides and the more accentuated median ridge. The species is fairly common in Lower Marine sandstone at Jackson's Hill, between Pokolbin and Cessnock.

(c) *The Lochinvar Shale Fauna.*

Specimens of a *Eurydesma* of the *hobartense* type have the same general proportions as *Leiomyalina antarctica*, Frech (*Eurydesma hobartense*, Johnston) of Tasmania, which occurs in both the Upper and the Lower Marine Series of Tasmania, but in New South Wales, with this exception, appears to be confined to Upper Marine strata.

There would appear, from the four specimens examined, to be no definite specific difference between the Gosforth and the typical species, the former presenting the same convexities of valve surface, the same general contour, and similar umbonal thickness and structures. The sole variation is in size, the apparently adult Gosforth specimen attaining only about two-thirds the dimensions of the type forms.

Conclusion.

It would appear, then, from field and laboratory observation, that the three fossiliferous horizons examined, that is to say, the limestone, plant-bearing sandstone and *Eurydesma hobartense* beds, are definitely of Permo-Carboniferous age, and that the base of the Permo-Carboniferous system is to be placed, as originally suggested by Professor David, at the base of the Lochinvar shales.

LANDSLIDES NEAR PICTON AND NOTES ON THE LOCAL VEGETATION.

By R. H. Cambage, F.L.S.

(With Plates X., XI.)

(Read before the Royal Society of New South Wales, November 5, 1924.)

On the northern side of the railway line between Douglas Park and Picton is a somewhat broken escarpment known in part as Donald's Range, and reaching a general elevation of nearly 1000 feet above sea level, while it approximates 500 feet above the railway line. In the valleys formed by various spurs extending downwards from this slight escarpment are a series of landslides, some of which in appearance are not unlike glacial moraines, though their origin is very different.

In the Blue Mountains, which reach an elevation up to 3500 feet, there is a thick overburden of Hawkesbury Sandstone, below which is a considerable mass of Permian shales, and, as is well known, the weathering of these weaker shales undermines the overlying sandstone, inducing it to break off in large portions and fall into the depths below, leaving gigantic sandstone escarpments above. Rockslides occur from time to time, but as there is such a preponderence of rock of a sandy nature, large quantities of sand are produced, and in the steeper portions of the mountains soon washed away, and moraine-like slides do not occur.

An examination of the Picton area discloses a set of conditions different from those on the Blue Mountains, chiefly because of the dissimilarity in the texture of the rocks of the two localities, and also the much lower elevations of the small escarpments around Picton.

Some of these landslides which may be seen from the passing train occur on Portions 15 of 500 acres, and 146 of 2000 acres, Parish of Picton, County of Camden.

The summit of Donald's Range forms a small plateau (Plate XI., Fig. 1), and is composed of a somewhat reddish sandstone, the colour being due to the presence of iron. This constitutes the upper stage of the Wianamatta beds of the Triassic formation, and has a general thickness, according to Mr. T. L. Willan, of about 300 feet*. In weathering, it produces slight escarpments, though the hill tops are often somewhat rounded.

Underlying this sandstone, and forming the middle stage of the Wianamatta beds, is a slightly less siliceous sandstone containing some shaley deposits, and having a thickness of approximately 200 feet, and this sandstone is superimposed on the Wianamatta shales, which in this locality have a thickness of about 200 feet, and constitute the lower stage of the series. These shales, which produce a clay soil when decomposed, rest on the Hawkesbury Sandstone, which latter, though exposed in the Nepean River close by, plays no part in the formation of the landslides under discussion.

Analyses of the upper and lower sandstones, which constitute the upper and middle stages of the Wianamatta beds, have been made by Mr. H. P. White, of the Mines Department, as follows:—

---

* The Geology of the Sydney District (in manuscript), by T. L. Willan, B.Sc.

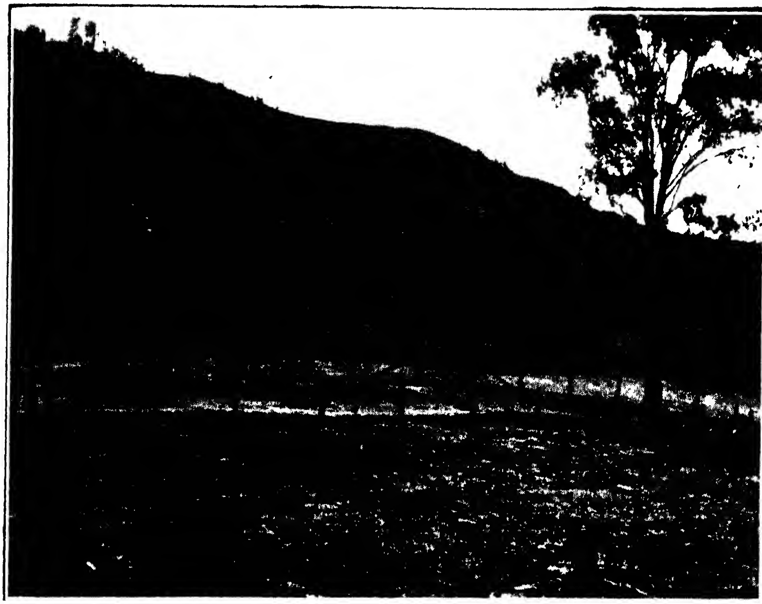


Fig. 1.—Landslides on side of Donald's Range, Portion 15.

Fig. 2.—Closer view of part of Fig. 1.

		Upper Stage. Incomplete Analysis.		Middle Stage or Lower Sandstone. Incomplete Analysis.
Silica	(SiO_2)	73.72	..	68.64
Alumina	(Al_2O_3)	11.74	..	16.31
Ferric oxide	(Fe_2O_3)	4.60	..	3.90
Ferrous oxide	(FeO)	.81	..	.81
Manganous oxide	(MnO)	.02	..	.04
Calcium oxide	(CaO)	.44	..	.68
Magnesium oxide ..	(MgO)	1.08	..	.92
Soda	(Na_2O)	1.64	..	1.08
Potash	(K_2O)	1.14	..	1.24
Sulphur trioxide	(SO_3)	trace	..	trace
Phosphoric anhydride	(P_2O_5)	.08	..	.22
Titanium dioxide	(TiO_2)	.22	..	.32
Water		4.28	..	5.64
Organic matter		traces	..	traces
		99.77		99.80

It is known that these sandstones are often calcareous, being so referred to by the Rev. W. B. Clarke*, and as the samples in both these cases were collected on the surface, it is possible a proportion of the lime has leached out.

In the early days of Picton some form of lime was obtained in Stonequarry Creek, about a quarter of a mile above Maldon†. The lime was brought along in solution in the water which came from the overlying calcareous sandstone deposits referred to, and precipitated as incrustations on the face of a small cliff of Hawkesbury Sandstone, and it was this secondary limestone or travertine which was burnt for lime.

* Remarks on the Sedimentary Formations of New South Wales, p. 73, by Rev. W. B. Clarke, M.A., F.R.S., etc.

† "Early Days of Picton," by Rev. James Steele. Journ. and Proc.. Aus. Hist. Soc., Vol. I., Part IX., 165 (1904).

Both of these sandstones are of a somewhat porous nature, and in wet weather hold a considerable quantity of water. Small springs occur towards the base of the lower sandstone. When well saturated, the disjointed lower sandstone loses its coherence and moves downwards, to some extent slipping on the underlying shales, and the earth formed from decomposed sandstone and shale, is forced by gravitation into the nearest valley. In no case, however, does the landslide appear to reach the bottom of the hill.

One of the landslides on Portion 15 (Plate X) covers an area of about two acres, and the lower or advance face is four feet high, rising to ten feet high at about twelve feet back from the face. On the eastern side of the same landslide, at about three chains up the hill, the height of the accumulated earth and rock is about fifteen feet.

It is clear that a line of weakness exists near the junction of the sandstone and shale, and this should always be taken into consideration in the construction of engineering works in the locality.

It is probable that the occurrence of these landslides has been stimulated by the clearing away of some of the vegetation, but there is evidence of slipping or faulting towards the higher portions which probably antedates the time when clearing operations were carried on to any extent, especially near the summit. In one place on Portion 15 there is a level faulted block over 50 feet lower than the summit of the plateau, and on which is growing a large tree of *Eucalyptus tereticornis,* probably at least from 70 to 100 years old. This tree probably post-dates the movement, or was very young when the block of land on which it is standing slipped downwards.

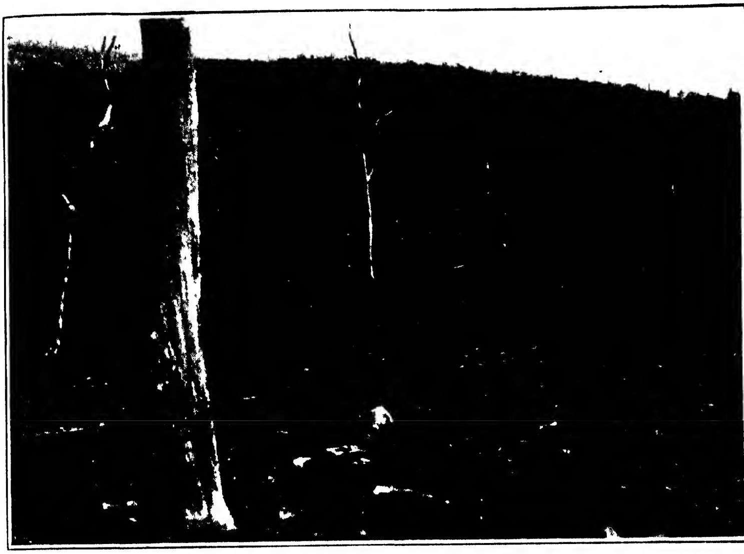


Fig. 1.—Erosion of Plateau on Donald's Range.

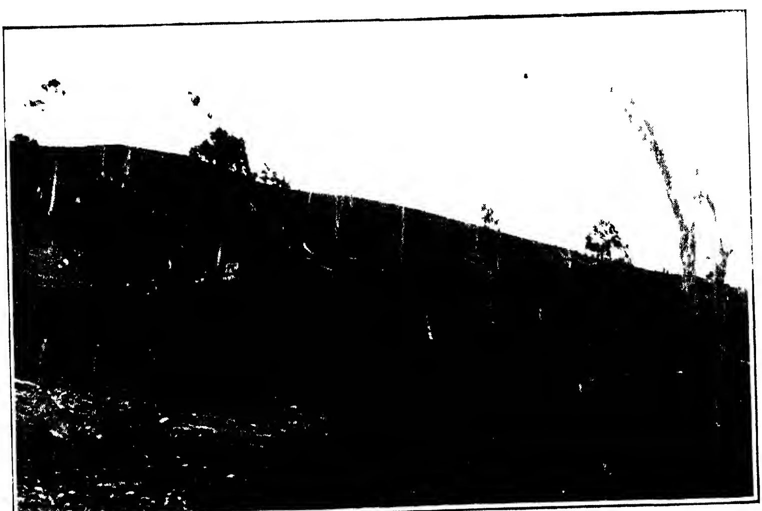


Fig. 2.—Landslide, which occurred in 1922, on southern slope of ridge eastward of Vault Hill, Picton.

It is evident this species was very common on the hills in this district before the days of settlement, for George Caley, Sir Joseph Banks' seed and plant collector, visited the locality in 1802 and 1804, and wrote of some of the hills as "abounding with she-oaks" and "making good pasture."*

Several trees of *Brachychiton populneus* (*Sterculia diversifolia*), the well known Kurrajong, were noticed on the sandstone areas. This species is very common in the western districts of this State, usually growing on soils fairly well to heavily charged with lime, and in some cases it is practically the only tree vegetation on extensive outcrops of limestone. It usually avoids soils derived from highly siliceous rocks, though a few exceptions to this rule have been noticed. Although dotted along the coastal district at various points, it is not nearly so common east of the Main Divide as west of it, and seeing that it avoids the highly siliceous Hawkesbury Sandstone, and the more basic portions of the Wianamatta Shale, it is remarkable that it should have sought out these calcareous sandstone beds near Picton and so established itself in that district.†

* Historical Records of New South Wales, Vol. V., 724.

† For a paper on a similar area near Richmond, see "Note on the Occurrence of a Limestone Flora at Grose Vale," by W. M. Carne, Proc. Linn. Soc. N.S.Wales, Vol. XXXV., 849 (1910).

ACACIA SEEDLINGS, PART X.

By R. H. CAMBAGE, F.L.S.

[With Plates XII.-XV.]

(*Read before the Royal Society of N.S. Wales, Dec. 3, 1924.*)

SYNOPSIS:

VITALITY OF SEEDS IN SEA-WATER.
PERIOD BETWEEN FLOWERS AND RIPE PODS.
DESCRIPTION OF SEEDLINGS.

Vitality of Seeds in Sea-Water.

A seed of *Acacia podalyriæfolia* germinated after having been immersed in sea-water for five years.

A seed of *Acacia melanoxylon* from Jenolan Caves was placed in boiling water and planted after having been immersed in sea-water for seven and a half years. At the end of two weeks the seed was taken out of the soil and examined, and as it was found to be perfectly hard it was again placed in boiling water and planted, after which it germinated. This latter instance is regarded as a record for this experiment.

Period between Flowers and Ripe Pods.

Although *Acacia* flowers may be found all the year round, a great many species flower in the winter and early spring, and in these cases the fruits commonly ripen in four or five months. There are some species, however, which flower in midsummer, about November, December and January, and it is remarkable that the seeds of some of these species do not ripen for about twelve months, so that the last year's ripe pods are seen on the trees among the flowers of the following year.

Among those species which take about a year to ripen their pods are:—*A. cyclopis, A. elata, A. mollissima* and *A. pauciglandulosa.*

A. cyclopis flowers about December and the resultant pods ripen in the following November and December.

A. elata flowers in December and January and the pods ripen one year later.* A tree of this species in full flower at Mittagong in the middle of January was also laden with ripe pods, which were falling. By the following June the young pods were about one inch long, but no flower buds had developed. Late in October the pods were up to four and a half inches long, though still quite green, and the flower buds were present. By the end of December the pods were ripe and the tree was in bloom.

Similar conditions were noted on a tree of *A. mollissima* at Mittagong, except that the various stages were reached about a month earlier than in the case of *A. elata,* and the pods, which do not attain the size of those of *A. elata,* were up to about three inches long in October.

Early in August, trees of *A. pauciglandulosa,* which flowered early in the year, and are growing near the Biological Survey Station, National Park, had green pods about two inches long, but no flower buds. Ripe pods have been gathered at the end of December from trees of this species which were flowering at Jervis Bay.

Description of Seedlings.

UNINERVES—(Brevifoliæ).

ACACIA ANCEPS, D C.—Seeds from Yorkes Peninsula, South Australia (Dr. R. H. Pulleine). (Plate XII., Numbers 1 to 3.)

* See "Botany for Australian Students, p. 204, by Agnes A. Brewster and Constance M. Le Plastrier.

Seeds, dark brown, oblong-oval to obovate, 4 to 5.5mm. long, 3mm. broad, 1.5mm. thick.

Hypocotyl terete; light brown above soil, spreading into a flange at base, 1 to 2.7cm. long, 2 to 3mm. thick at base, about 1mm. at apex.

Cotyledons sessile, auricled, oblong to oblong-obovate, apex rounded, 5.5 to 6mm. long, 3.5 to 4mm. broad, upperside green, underside brownish-green, with a few longitudinal lines.

Stem at first angular, becoming terete except where affected by decurrent leaf-stalks, green on shady side, greenish-brown on side exposed to the sun, glabrous. First internode 0.5mm.; second 0.5 to 2mm.; third 1 to 3mm.; fourth to sixth 1mm. to 1cm.; seventh to ninth 2mm. to 1.5cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 6mm., glabrous; leaflets three to four pairs, oblong-acuminate, 3 to 7 mm. long, 1 to 2mm. broad, upperside green, underside pale green; rachis 6 to 8mm., with terminal seta; stipules reduced to scales.

No. 2. Abruptly bipinnate, petiole 3 to 6mm., glabrous, with terminal seta; leaflets two to three pairs, oblong-acuminate, apical pair obovate, about 3mm. long, 1 to 1.5mm. broad, upperside green; rachis 3 to 7mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 5mm. to 1.3cm., glabrous or sometimes with a few scattered hairs; leaflets three to six pairs, 3 to 5mm. long; rachis 5mm. to 1cm.; stipules reduced to flat acuminate scales 1mm. long.

Nos. 5 to 7. These may be phyllodes, or abruptly bipinnate, petiole 8mm. to 2cm., sometimes, in the case of No. 7, dilated to 2mm. broad, the midrib below the centre

of the lamina, the margins nerve-like; leaflets five to six pairs; rachis 6mm. to 1.8cm.

Nos. 8 to 12. Obovate phyllodes, mucronate, 1.5 to 4.5cm. long, 5mm. to 1.3cm. broad, the midrib slightly below the centre of the lamina, especially in Nos. 8 to 10, penniveined, the margins nerve-like.

On a plant one foot high the upper lanceolate-obovate to almost oblong phyllodes may be up to 7cm. long, 1.6cm. broad, with a gland on the upper margin at about 1 to 1.5cm. from the base.

UNINERVES—(Racemosæ).

ACACIA FALCIFORMIS DC. (*A. penninervis* Sieb. var. *falciformis* Benth.) Seeds from Jenolan Caves. Plate XII., Numbers 4 to 6.)

Seeds black, oblong-oval to oval, 5 to 7mm. long, 3 to 4.5mm. broad, about 2mm. thick.

Hypocotyl terete, reddish-brown above soil, 1.3 to 2.5cm. long, about 2.5mm. thick at base, 1 to 1.5mm. at apex, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, 6mm. long, 4mm. broad, soon becoming revolute and cylindrical, upperside green to greenish-red, underside brownish-red.

Stem terete, brownish-red, becoming green when the plant reaches a few feet high, glabrous. First internode 0.5 to 1mm.; second 1 to 5mm.; third 3 to 5mm.; fourth to sixth 3 to 8mm.; seventh 7mm. to 1.2cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 5mm., often with gland, brownish-red, glabrous; leaflets five to seven pairs, oblong-acuminate, often mucronate, 7mm. to 1cm. long, 1.5 to 2.5mm. broad, upperside reddish-green, underside brownish-red; rachis 1.2 to 1.7cm., with terminal seta.

Acacia anceps (1 – 3); *A. falciformis* (4 – 6); *A. notabilis* var. (7 – 9)
A. ligulata (10 – 12).

Three-fifths Natural Size.

No. 2. Abruptly bipinnate, petiole 5 to 7mm., reddish-brown, usually with gland, glabrous, with terminal seta; leaflets four to five pairs, up to 6mm. long, 3mm. broad, the basal pair sometimes very small, underside reddish-brown; rachis 7mm. to 1.4cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 1.3 to 1.9cm., sometimes vertically dilated to 2mm. wide in the case of No. 4, with a strong nerve along lower margin, gland towards base on upper margin; leaflets five to nine pairs; rachis 1 to 2.8cm.

Nos. 5 and 6. Abruptly bipinnate, sometimes with two pairs of pinnæ, petiole 1.8 to 3.7cm., vertically dilated in some cases to 8mm., the midrib below the centre of the lamina, gland on upper margin; leaflets nine to twelve pairs; rachis 2 to 3.2cm.

No. 7. This may be a phyllode, or abruptly bipinnate, petiole 3 to 3.7cm., vertically dilated to 1.2cm. broad; leaflets ten to twelve pairs.

Nos. 8 to 12. Lanceolate—falcate, greyish green phyllodes up to 7cm. long, 2cm. broad, with the midrib above the centre of the penniveined lamina, margins nerve-like, gland towards base.

UNINERVES—(Racemosæ).

ACACIA NOTABILIS F.v.M. var. Seeds from Mount Babbage, Flinder's Range, South Australia (Dr. W. G. Woolnough). (Plate XII, Numbers 7 to 9.)

Seeds dull black, obovate to almost orbicular, 5 to 7mm. long, 4 to 5mm. broad, 2 to 3mm. thick.

Hypocotyl terete, reddish to red above soil, spreading into flange at root, 2 to 3cm. long, 2mm. thick at base, 0.8 to 1mm. thick at apex.

Cotyledons sessile, auricled, oblong-oval, upperside green, underside greenish-red, with raised centre line, 7 to 8mm. long, 4 to 5mm. broad, becoming revolute and in some cases cylindrical.

Stem terete, green to reddish-green, glabrous. First internode 0.5 to 1mm.; second 1 to 3mm.; third 3 to 6mm.; fourth and fifth 6mm. to 1.1cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 5mm., glabrous; leaflets five to six pairs, oblong-acuminate, often mucronate, 4mm. to 1cm. long, 2 to 3mm. broad, upperside green, underside paler; rachis 1 to 2.4 cm., glabrous, with terminal seta.

No. 2. Abruptly bipinnate, petiole 1 to 1.3cm., very slender, or sometimes slightly dilated in middle portion, up to 0.5mm., rarely with small gland, glabrous, with terminal seta; leaflets three to four pairs, usually mucronate, smaller than those of No. 1; rachis 9mm. to 1.3cm., with terminal seta.

Nos. 3 to 5. Lanceolate—falcate, greenish-grey, penniveined phyllodes, 3 to 7cm. long, 7mm. to 1.5cm. broad, margins nerve-like. A gland was not noticed on the early phyllodes, but it may be seen on subsequent ones.

Seedlings came up in one week after seeds were planted in January, and the No. 3 leaf developed into a phyllode up to 1cm. long in two weeks later or three weeks from the time the seed was planted. As the result of growing in a hot climate with a low and uncertain rainfall, this species has evidently developed the character of being able to quickly establish itself once the seed gets sufficient moisture to cause it to germinate.

This is the eighth seedling described in this series where the No. 3 leaf may be reduced to a phyllode, the previous cases being *A. alata*, *A. aspera*, *A. Bancrofti*, *A. excelsa*, *A. flexifolia*, *A. Oswaldi* and *A. tetragonophylla*.

It is not certain that this plant has been correctly identified, and reference will be made to the matter in a later paper.

UNINERVES—(Racemosæ).

ACACIA LIGULATA A. Cunn. (*A. salicina* Lindl. var *Wayæ* Maiden). Seeds from Botanic Gardens, Sydney (J. H. Maiden). (Plate XII, Numbers 10 to 12.)

Seeds dull black to brownish-black, oblong-oval to ovate, 3.5 to 4.5mm. long, 2 to 3mm. broad, about 1.5mm. thick.

Hypocotyl terete, pale green, 8mm. to 1.5cm. long, 1 to 1.3mm. thick at base, about 0.7mm. at apex.

Cotyledons sessile, oblong, apex rounded, 5 to 6mm. long, 2mm. broad, upperside brownish-green, underside brown to puce, sometimes slightly furrowed, usually remaining erect and falling early.

Stem terete, glabrous. First internode 0.5 to 1mm.; second 0.5 to 5mm.; third 1 to 7mm.; fourth to seventh 2mm. to 1.5cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 1 to 5mm., glabrous; leaflets three pairs, oblong-acuminate, often mucronate, about 3mm. long, 1 to 2mm. broad, upperside green, underside paler, margins often red, with sometimes a few scattered hairs; rachis about 5mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 3mm. to 1cm., with terminal seta; leaflets three to four pairs, oblong to obovate, sometimes with a few scattered hairs along the margins, up to 3mm. long, 1.5mm. broad; rachis 6 to 7mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 7mm. to 2.3cm., slender, glabrous; leaflets four to five pairs; rachis 7mm. to 1.6cm.

Nos. 5 to 7. Abruptly bipinnate, petiole 1 to 3.2cm., sometimes vertically dilated up to 1mm. broad, the midrib slightly below the centre of the lamina; leaflets four to seven pairs; rachis 8mm. to 2cm.

Nos. 8 and 9. Although No. 9 may be a phyllode, both may be abruptly bipinnate, petiole 3 to 4.7cm., dilated up to 2 and 3mm. broad; leaflets seven to eight pairs, up to 5mm. long; rachis 1.7 to 2.4cm.

Nos. 10 to 12. Lanceolate phyllodes, 3 to 4cm. long, 3 to 4mm. broad, with central nerve.

UNINERVES—(Racemosæ).

ACACIA LEPTOPETALA Benth. Seeds from Nindigully via Thallon, southern Queensland (Miss I. Tosh). (Plate XIII, Numbers 1 to 3.)

Seeds dull black, obovate-oval, 4 to 5mm. long, 3 to 4mm. broad, 1.5 to 2mm. thick.

Hypocotyl terete, pale, 1.7 to 3.2cm. long, 1.3 to 2mm. thick at base, about 1mm. at apex.

Cotyledons sessile, slightly auricled, obovate-oblong, 6 to 7mm. long, 3 to 4mm. broad, upperside green, underside yellowish with reddish tint towards apex, to brownish-green and reddish-brown, often with a few longitudinal lines.

Stem at first angular, becoming terete, brownish-red. First internode 0.5mm.: second 0.5 to 2mm.; third to ninth 1mm. to 1cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 3 to 5mm., glabrous; leaflets two pairs, oblong-acuminate, the apical pair sometimes obovate, 4 to 6mm. long, 1.5 to 3mm. broad, venation fairly distinct, upperside green, underside paler; rachis 3 to 5mm.; with terminal seta.

Acacia leptopetala (1 – 3); *A. complanata* (4 – 6).
Seven-tenths Natural Size.

No. 2. Abruptly bipinnate, petiole 5mm. to 1.2cm., with terminal seta; leaflets two to four pairs, oblong-acuminate to obovate, 2 to 5mm. long, up to 2mm. broad; rachis 5 to 8mm., with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, petiole 6mm. to 1.2cm.; leaflets two to five pairs; rachis 5mm. to 1.5cm.

Nos. 6 to 8. Abruptly bipinnate, petiole 7mm. to 2.3cm.; leaflets four to six pairs; rachis 8mm. to 2.3cm.

Nos. 9 to 12. Abruptly bipinnate, petiole 7mm. to 5.3cm., sometimes dilated up to 1mm. in the case of No. 9, and 7mm. in No. 12; leaflets four to eight pairs; rachis 8mm. to 2.6cm.

Nos. 13 to 20. These may be phyllodes, or abruptly bipinnate, petiole from 1 to 5cm., sometimes dilated up to 7mm. broad, the margins nerve-like, the midrib near the lower margin; leaflets four to six pairs, often mucronate; rachis 7mm. to 1.7cm.

Nos. 21 to 25. Usually lanceolate phyllodes, 5 to 6cm. long, about 6 to 7mm. broad, narrowed towards the base, the midrib either slightly below or in the centre of the lamina which is obscurely penniveined, the margins nerve-like.

PLURINERVES—(Nervosæ).

ACACIA COMPLANATA A. Cunn. Seeds from Eidsvold, Queensland (Dr. T. L. Bancroft, per J. H. Maiden). (Plate XIII, Numbers 4 to 6.)

Seeds brown, oblong-oval, areole distinct, 4mm. long, 2.5 to 3mm. broad, 2mm. thick.

Hypocotyl terete, pale green to pinkish-green above soil, 1.5 to 2cm. long, 2mm. thick at base, about 0.8 to 1mm. at apex.

Cotyledons sessile, auricled, oval to obovate, 5 to 6mm. long, 3 to 4mm. broad, upperside green, underside red.

Stem angular, reddish-brown, glabrous. First internode 0.5mm.; second 1 to 2mm.; third 2 to 3mm.; fourth to fifth 3mm. to 1cm.; sixth to eighth 4mm. to 1.2cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 5mm., glabrous; leaflets one to two pairs, oblong-acuminate to obliquely obovate, sometimes mucronate, 3 to 7mm. long, 1 to 4mm. broad, upperside green to reddish-green, underside red; rachis 2 to 3mm., with terminal seta; stipules 1mm. long.

No. 2. Abruptly bipinnate, petiole about 6 to 7mm., with terminal seta; leaflets two pairs, usually obovate, mucronate, up to 4mm. long, 3mm. broad, upperside green, underside reddish to red; rachis 3 to 5mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole up to 1.2cm., in some cases No. 4 may be dilated to 1mm. broad, glabrous; leaflets two pairs, up to 6mm. long, 4mm. broad; rachis about 5mm.

Nos. 5 to 9. Phyllodes oblong to oval, obtuse, 1 to 4cm. long, 4mm. to 1.4cm. broad, with from three to five prominent longitudinal nerves, and a few fine veins between them, often with a faint gland towards the base.

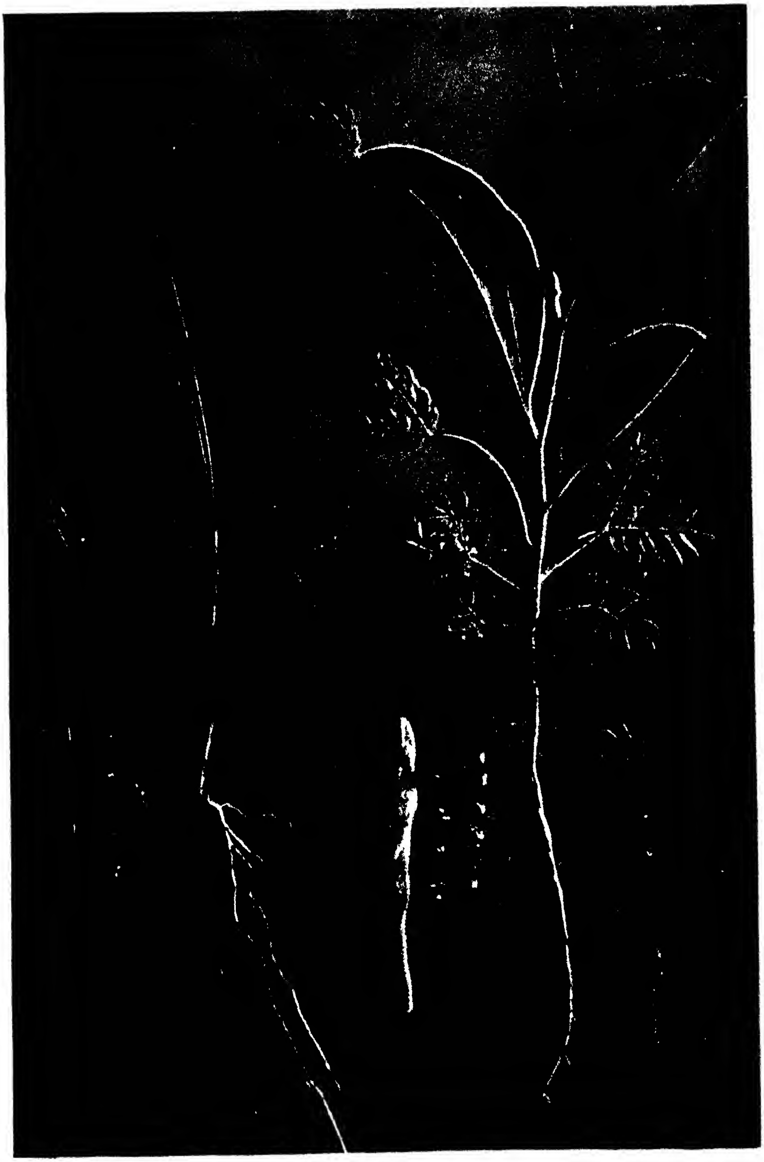
JULIFLORÆ—(Falcatæ).

ACACIA DORATOXYLON A. Cunn. Seeds from Denman (J. H. Maiden), Cobar (Archdeacon F. E. Haviland), and Wyalong. (Plate XIV, Numbers 1 to 3.)

Seeds black, oblong, 3 to 5mm. long, 2mm. broad, 1 to 1.5mm. thick.

Hypocotyl terete, brownish-red above soil, about 1.5cm. long, 1mm. thick at base, about 0.5mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded. 5mm. long, 2mm. broad, upperside green, underside pale green to red.



Acacia doratoxylon (1 – 3); *A. humifusa* (4 – 6).
Nine-tenths Natural Size.

Stem at first slightly angular, soon becoming terete, greenish-grey to brown, at first slightly tomentose, becoming glabrous. First internode 0.5mm.; second 1 to 2mm.; third to fifth 1 to 4mm.; sixth to ninth 2 to 8mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4mm., green to reddish-brown; leaflets two pairs, oblong-acuminate, 3 to 7mm. long, 1.5 to 3mm. broad, upperside green, underside pale pink to red; rachis 2 to 5mm., brownish-green, with terminal seta.

No. 2. Abruptly bipinnate, petiole 4mm. to 1.4cm., with terminal seta; leaflets two to three pairs, oblong-acuminate, the apical pair often obovate, 4 to 5mm. long, 2 to 3mm. broad; rachis 3 to 6mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 1.3 to 2.7cm., sometimes pilose; leaflets two to four pairs; rachis 5mm. to 1cm.

Nos. 5 and 6. Abruptly bipinnate, petiole 1.5 to 3.5cm., dilated to 1mm. broad in the case of No. 5, and 3mm. in No. 6; leaflets four to five pairs, margins ciliate; rachis 6mm. to 1.1cm.

Nos. 7 to 10. Lanceolate, slightly falcate, sometimes linear phyllodes, often with a recurved point, 3 to 8cm. long, 3 to 5mm. broad, with a fairly prominent central nerve and numerous fine parallel veins, one on each side of the central nerve usually being slightly more conspicuous than the rest.

JULIFLORÆ—(Dimidiatæ).

ACACIA HUMIFUSA A. Cunn. Seeds from Stanley Island, Flinders Group, north Queensland (C. Hedley). (Plate XIV, Numbers 4 to 6.)

Seeds black, oblong, 4 to 5mm. long, 2 to 2.5mm. broad, about 1.5 to 2mm. thick.

Hypocotyl terete, brownish-red above soil, 1.5 to 2.2cm. long, 2mm. thick at base, about 1mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 to 6.5mm. long, 3 to 3.5mm. broad, upperside green, underside brownish-green to reddish-brown and red, sometimes with a warty protuberance.

Stem at first slightly angular, becoming terete, ashy grey, tomentose. First internode 0.5mm.; second 1 to 3mm.; third to fifth 1 to 5mm.; sixth to ninth 4mm. to 1.8cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3mm., glabrous or with a few scattered hairs; leaflets three pairs, oblong-acuminate, 4 to 6mm. long, 2 to 3.5mm. broad, upperside green, underside paler; rachis 3 to 5mm., with terminal seta; stipules about 1mm. long.

No. 2. Abruptly bipinnate, petiole 4 to 8mm., pilose to hirsute, with terminal seta; leaflets three to four pairs, upperside green, underside paler, venation distinct, margins ciliate; rachis 3 to 6mm., with terminal seta; stipules about 1mm. long.

Nos. 3 and 4. Abruptly bipinnate, petiole 4mm. to 1.2cm., hirsute; leaflets three to five pairs, oblong-acuminate, margins ciliate; rachis 4mm. to 1.1cm., pilose.

Nos. 5 and 6. Abruptly bipinnate, petiole 8mm. to 2.7cm., pilose to hirsute, sometimes vertically flattened from 1 to 2mm. broad in the case of No. 5, and up to 6mm. in the case of No. 6, with a strong nerve along or near the lower margin, and a finer one concave to it above; leaflets four to seven and rarely eight pairs; rachis 6mm. to 1.6cm.

Nos. 7 and 8. These may be phyllodes, or abruptly bipinnate, petiole from 2.3 to 5.2cm. long, and up to 1.5cm. broad, usually with two longitudinal veins, the lower

one the more prominent and not far from the lower margin, the upper vein not always reaching the apex, but sometimes terminating in several veinlets, pilose to hirsute, particularly along the edges, the margins nerve-like; leaflets five to seven pairs; rachis 1 to 1.7cm.

Nos. 9 to 12. Obliquely ovate somewhat falcate phyllodes, tomentose especially towards the base, with usually three prominent nerves starting from the lower margin at the base but not confluent at the apex.

BIPINNATÆ—(Botryocephalæ).

ACACIA CARDIOPHYLLA A. Cunn. Seeds from Wyalong, New South Wales. (Plate XV, Numbers 1 to 3.)

Seeds black, oblong, apex rounded, 5 to 6mm. long, 2.5mm. broad, 1.5 to 2mm. thick.

Hypocotyl terete, brownish-pink to brownish-red above soil, 1.5 to 2.5cm. long, 1 to 2mm. thick at base, 0.7 to 1mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, about 7mm. long, 3mm. broad, upperside green to brownish-green and brown, underside from yellowish-green to brown and brownish-red, sometimes with a raised centre line, becoming horizontal, revolute and cylindrical in a few days.

Stem terete, hirsute to pubescent, greyish-green. First internode 0.5mm.; second 1 to 2mm.; third 2 to 4mm.; fourth 3 to 7mm.; fifth to sixth 4mm. to 1cm.; seventh to eighth 6mm. to 1.2cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3mm.; leaflets three to five pairs, oblong-acuminate, 5 to 6mm. long, 1.5 to 2mm. broad, upperside green, underside paler; rachis 6 to 9mm., with terminal seta.

No. 2. Abruptly bipinnate, rarely with two pairs of pinnæ, petiole 4 to 8mm., with terminal seta; leaflets three to seven pairs; rachis 3mm. to 1cm., with terminal seta.

In one case No. 2 appeared as an apparent tripinnate leaf, but with the terminal seta present.*

No. 3. Abruptly bipinnate, often twice pinnate, common petiole up to 1.2cm., pilose; leaflets up to nine pairs on the terminal pair of pinnæ; rachis 7mm. to 1.5cm.; stipules about 1mm. long.

Nos. 4 and 5. Abruptly bipinnate, with from two to four pairs of pinnæ, common petiole 7mm. to 3cm., hirsute; leaflets five to eleven pairs, oblong-acuminate to sometimes ovate, the apical pair obovate, mucronate, 2 to 4mm. long, 0.7 to 2mm. broad, venation distinct on underside, the margins ciliate; rachis up to 1.8cm.

Nos. 6 to 9. Abruptly bipinnate, with from three to eleven pairs of pinnæ, common petiole 1.2 to 4.5cm., hirsute; leaflets six to thirteen pairs; rachis up to 1.5cm.

Leaf No. 14 may have up to seventeen pairs of pinnæ, leaflets up to twelve pairs, ovate, 1.5 to 2mm. long, 0.6 to 1mm. broad. A mature plant may have up to twenty-one pairs of pinnæ, and sometimes fifteen pairs of leaflets.

BIPINNATÆ—(Pulchellæ).

ACACIA GILBERTI Meissn. Seeds from Western Australia (E. E. Pescott). (Plate XV, Numbers 4 to 6.)

Seeds shiny black to brownish-black, oval to oblong-oval and ovate, about 4mm. long, 2 to 2.5mm. broad, 1.5mm. thick.

Hypocotyl terete, red above soil, 1.6 to 3.2cm. long, about 1.5mm. thick at base, 0.5 to 0.7mm. at apex.

---

* See Proc. Roy. Soc. N.S.Wales, 1917, Vol. LI., p. 398.

Acacia cardiophylla (1 - 3), *A Gilberti* (4 - 6).

Two-thirds Natural Size.

Cotyledons sessile, oblong to oblong-oval, 5 to 6mm. long, 3mm. broad, upperside green, underside yellowish-green to pinkish-green and brownish-red, remaining erect and soon falling.

Stem at first angular, becoming terete, greyish-brown to reddish-brown, glabrous. First internode 0.5mm.; second to fourth 3mm. to 1.6cm.; fifth to sixth 4mm. to 1.7cm.; seventh to tenth 6mm. to 2.2cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 3 to 7mm., glabrous; leaflets two pairs, oblong-acuminate to obovate—lanceolate, 4 to 9mm. long, 2 to 3mm. broad, upperside green, underside paler; rachis 2 to 3mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole up to 1.1cm., with terminal seta; leaflets two to three pairs, oblong-acuminate to obovate-lanceolate; 4 to 9mm. long, 2 to 4mm. broad; rachis 5mm. to 1cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 4 to 8mm., sometimes with gland at base of pinnæ, glabrous; leaflets three to five pairs; rachis 1 to 2.2cm.

Nos. 5 to 8. Abruptly bipinnate, petiole 5 to 8mm., usually with gland at base of pinnæ; leaflets three to seven pairs, obovate-lanceolate, up to 1.1cm. long, 4mm. broad; rachis 7mm. to 3.5cm.

Nos. 9 and 10. Abruptly bipinnate, sometimes with two pairs of pinnæ, common petiole up to 2cm., with a gland at the base of the first and sometimes the second pair of pinnæ; leaflets five to six pairs; rachis 1.5 to 2.8cm.

On a plant one foot high there may be a few leaves with three pairs of pinnæ, and a leaflet may be rarely 1.6cm. long, and 9mm. broad.

In one case an apparent tripinnate leaf was noticed, but the terminal seta was present.

EXPLANATION OF PLATES.

Plate XII.

Acacia anceps DC.

1. Cotyledons. Yorkes Peninsula, South Australia, (Dr. R. H. Pulleine).
2. Seeds.
3. Pinnate leaf, bipinnate leaves and phyllodes.

Acacia falciformis DC.

4. Cotyledons. Jenolan Caves, N.S. Wales.
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Portion of pod and seeds.

Acacia notabilis F.v.M. var.

7. Cotyledons and pinnate leaf. Mount Babbage, Flinders Range, South Australia, (Dr. W. G. Woolnough).
8. Pinnate leaf, bipinnate leaf and phyllodes.
9. Portion of pod and seeds.

Acacia ligulata A. Cunn.

10. Cotyledons and opposite pair of pinnate leaves. Botanic Gardens, Sydney, (J. H. Maiden).
11. Opposite pair of pinnate leaves, bipinnate leaves and phyllodes.
12. Pod and seeds.

Plate XIII.

Acacia leptopetala Benth.

1. Cotyledons and opposite pair of pinnate leaves. Nindigully via Thallon, southern Queensland, (Miss I. Tosh).
2. Pinnate leaves (detached), bipinnate leaves, and phyllodes.
3. Pod and seeds.

Acacia complanata A. Cunn.

4. Cotyledons and pinnate leaf. Eidsvold, Queensland, (Dr. T. L. Bancroft).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Seeds.

Plate XIV.

Acacia doratoxylon A. Cunn.

1. Cotyledons and pinnate leaf. Wyalong, N.S. Wales.
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

Acacia humifusa A. Cunn.

4. Cotyledons and pinnate leaf. Stanley Island, Flinders Group, north Queensland, (Charles Hedley).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds.

Plate XV.

Acacia cardiophylla A. Cunn.

1. Cotyledons and part of pinnate leaf. Wyalong.
2. Pinnate leaf and bipinnate leaves.
3. Pod and seeds.

Acacia Gilberti Meissn.

4. Cotyledons. Western Australia, (E.E. Pescott).
5. Opposite pair of pinnate leaves and bipinnate leaves.
6. Seeds.

THE ESSENTIAL OIL OF BORONIA SAFROLIFERA (CHEEL).

By A. R. PENFOLD, F.A.C.I., F.C.S.
Economic Chemist, Technological Museum, Sydney.

(*Read before the Royal Society of N.S. Wales, Dec. 3, 1924.*)

The botany of this rutaceous shrub has been fully described by Mr. E. Cheel, of the National Herbarium, Sydney, in the present Journal of the Society, pages 145-149. It is a small slender shrub with pretty pink flowers, superficially resembling *B. pinnata* at first glance, and is found growing close to the swampy parts of the heath country at Broadwater, Richmond River, N.S.W. On crushing the leaves between the fingers a pronounced odour of safrol is detected, and as shown under "Experimental" this phenol ether occurs in quantity in the essential oil of this plant, which has, therefore, been most aptly named by its author. I had the opportunity of examining the plant in the field at Broadwater in May last where it was observed growing close to *Boronia pinnata* and *B. thujona*, and am convinced that it is a distinct species. Although material for essential oil purposes was obtained in May, 1918, through the courtesy of the Colonial Sugar Refining Company Limited, I have been unable to obtain a further quantity sufficiently large for a thorough investigation despite repeated efforts made during the past six years. I have, therefore, been reluctantly compelled to publish the results of one distillation only, but it is necessary that this be done in order to pave the way for a number of contributions to follow shortly which will treat of the essential oils of other pinnate leaf Boronias.

The Essential Oil.

Only 28lb. 6oz. of the leaves and terminal branchlets of the plant in flower were collected at Broadwater, N.S.W.,

at the end of April, 1918, and upon distillation yielded 186 grams of oil, equal to 1.45%. This is the highest yield of oil obtained from any species of *Boronia* which has yet been examined. The oil was of a yellow colour, heavier than water, highly refracting, and possessed an odour of safrol modified by methyl eugenol. The principal constituents of the oil, so far identified, are d-*a*-pinene, safrol (about 70-75%), methyl eugenol, and a small quantity of a phenol and a paraffin. During the distillation a proportion of the oil floated on the surface of the condensed water, whilst the greater portion went to the bottom of the receiver. Each fraction was thus collected and examined separately.

Experimental.

The chemical and physical constants of the crude oil, together with those of the respective fractions before mixing, are given in the following table:—

Date	Locality	Percentage Yield of Oil.	Specific Gravity 15/15° C.
		Crude Oil.	
2/5/1918	Broadwater, Richmond River, N.S. Wales	1·45%	1·034
		Light fraction	
		0·26%	0·9805
		Heavy fraction	
		1·19%	1·045

Optical Rotation	Refractive Index, 20° C.	Ester No. hot sap 1½ hours, hot	Ester No. after acetylation
Crude	*Oil*		
+ 3·79	1·5180	13·67	29·33
Light	*fraction*		
+ 5·42	1·5016		
Heavy	*fraction*		
+ 3·42	1·5216		

The two fractions gave the following results on distillation at 773 mm.:—

Light oil, 41% distilled at 165-200° C., 41% at 200-237° C., and 15% at 240-250° C.

Heavy oil, 5% distilled at 170-200° C., 12% at 200-225° C., 72% at 225-240° C., and 10% at 240-248° C.

Determination of d-a-pinene.—On fractional distillation, at 10 mm. and 769.5 mm., of the fractions boiling below 200° C. at 773 mm., a portion was obtained distilling below 160° C. at the latter pressure, which possessed the following characters:—Specific gravity, 15/15° C., 0.8636; optical rotation, + 32°; refractive index, 20° C., 1.4676. On mixing with an equal volume of l-*a* pinene $[a]_{20}^{D}$ — 50.18°, a copious yield of nitrosochloride was obtained, which on purification melted and decomposed at 109° C.

Determination of safrol.—The original fractions boiling at 225-240° C. were redistilled at 10 mm. and 769.5 mm., and the resulting oil placed in a bath of solid carbon dioxide, when the frozen mass was transferred to a buchner filter funnel surrounded with ice. The crude safrol thus obtained possessed the following constants:—

Melting point, + 8° C.; boiling point, 231-233° C. at 769.5 mm.; specific gravity, 15/15° C., 1.09; optically inactive; refractive index, 20° C., 1.5331.

On isomerisation to iso-safrol and oxidation with Beckman's chromic acid solution heliotropine was obtained, which on purification through the bisulphite compound melted at 37° C.

Determination of methyl eugenol.—The filtrate from the frozen safrol was mixed with the small fraction distilling at 240-248° C. at 773 mm. and refractionated until only about 7 c.c. was obtained of boiling point 240-245° C.,

which possessed the following characters:—Specific gravity, 15/15° C., 1.062; optically inactive; refractive index, 20° C., 1.5312. It gave a strong reaction for methoxyl groups, and, on oxidation with potassium permanganate, veratric acid was obtained which, however, melted at 163-165° C. instead of 178-179° C. Careful examination showed it to be contaminated with a small quantity of piperonylic acid (M. Pt. 228° C.), from admixed safrol, hence the low melting point.

Determination of a phenol and paraffin.—On washing the crude oil with 5% sodium hydroxide solution 0.42% of an unidentifiable phenol was removed. The residue left in the still after removal of the safrol and methyl eugenol was found to contain a very small quantity of a paraffin of melting point 64-65° C.

I desire to express my thanks to Mr. E. Cheel for directing my attention to this species and for the authenticity of the material examined, and to Mr. R. C. Dixson, Sydney, for permission to publish the results.

A CHEMICAL EXAMINATION OF THE SEEDS OF THE "BUNYA BUNYA" (ARAUCARIA BIDWILLI HOOKER).—PART I.

By F. R. MORRISON, A.S.T.C., A.A.C.I.,

Assistant Economic Chemist, Technological Museum, Sydney.

[With Plate XIX.]

(Read before the Royal Society of N.S. Wales, Dec. 3, 1924.)

The botany of this stately tree is described in Bentham's "Flora Australiensis," vol. VI., p. 243 (Hooker, Lond. Journ. Bot. II, p. 503, t. 18). It is also described and figured in "Pines of Australia" (Baker and Smith), p. 360, 1910; in the same publication the chemistry of the bark and exudation is detailed.

The tree attains a height of 100 to 150 feet, and the cones which contain the seeds grow on the top-most branches. Each cone contains about 100 seeds. The seed is fig-shaped, and consists of a buff-colored shell which contains a white, pulpy, moist kernel covered with a brown "skin." The germ, yellow in colour, extends from the pointed end about 2 cm. along the centre of the kernel. An average seed measures 5 cm. long by 3 cm. at the widest part and weighs 16 grams. It consists of shell 23% and kernel 77%. The kernel contains 45% of water.

The dried meal (kernel) was found, on examination, to consist largely of starch; it is with this constituent that this paper is mainly concerned, the chemistry of the remainder being reserved for a subsequent communication.

Experimental.

Seeds from trees growing at Imbil, Queensland, were kindly supplied by the Queensland Forestry Office, Brisbane. Five hundred seeds, weighing 7.7 kilograms, were

crushed sufficiently to allow of the shells being removed, and the kernels, freed from skin, were passed through a mincer; the wet pulp thus obtained was exposed to air and sunshine until it became dry and brittle, after which it was finely ground. This "meal" contained 13.82% of hygroscopic moisture, and furnished 2.12% of ash on ignition.

(a) Extraction of constituents soluble in cold ether.

A quantity (524 grams) of the air dried meal was treated with successive portions of cold ether until all soluble matter had been removed; the ethereal solution was filtered and the solvent removed, 13.5 grams of a light-brown fat being obtained. This was apparently derived from the germ of the seed, and its chemistry will be described in a later communication.

The yield of fat, calculated on the air dried meal, was 2.6%.

(b) Treatment of the dried fat-free meal with cold alcohol.

Fifty grams of the dried fat-free meal were digested with cold alcohol for seven days with frequent agitation, but on filtering and removing the solvent only a trace of residue remained.

(c) Constituents soluble in cold water.

The dried fat-free meal was vigorously agitated with cold water and allowed to stand for 24 hours; at the end of that period the brown aqueous solution was filtered from the insoluble residue by suction, and an aliquot portion of the filtrate was evaporated to dryness on the water-bath, dried at 100° C. and weighed. Calculated on the original air dried meal the quantity of water soluble material was 7.72%.

The aqueous solution was concentrated to a syrup on the water-bath and four volumes of alcohol added; the

precipitate produced was retained on a filter paper, washed with alcohol and dried. The substance dissolved in water to form a mucilage. The aqueous solution was not precipitated by tannin or barium hydroxide. It did not reduce Fehling's solution, but after boiling the substance with dilute mineral acid Fehling's solution was readily reduced. A portion of the substance was hydrolysed by boiling with dilute sulphuric acid, the latter removed with barium hydroxide, and the barium sulphate removed by filtration; after concentrating the solution to a small bulk, prismatic plates crystallised from the solution, the osazone of which melted at 204° C. (melting point of dextrosazone). The water soluble constituent of the meal is apparently dextrin.

(d) Treatment of residue insoluble in cold water.

The insoluble residue from the cold water treatment of the fat-free meal was dried, and 100 grams were placed in a cloth bag and kneaded in successive portions of cold distilled water until all colloidal matter had passed into the water. The crude fibre, etc., remaining in the bag was dried at 100° C. and weighed. The quantity was equivalent to 7.93% calculated on the original air dried meal.

The vessel containing the water and colloidal matter was set aside for 24 hours at the end of which period a white deposit had formed at the bottom of the vessel. The clear supernatant liquid was completely removed by decantation, and the white starchy mass dried between folds of absorbent paper; when dry it was finely powdered. The yield calculated on the original air dried meal was 65.83%.

Identification of the Colloidal Material.

The air dried material (separated from the fibrous portion of the meal as described above) was almost white,

and possessed a characteristic starchy "feel" when rubbed between the thumb and forefinger. When heated in water it formed a viscous solution at 75° C.; the solution, when cold, gave with a dilute solution of iodine a deep blue coloration which disappeared on boiling, and reappeared, but with less intensity, on again cooling. Ammoniacal lead acetate threw down a white curdy precipitate from the starch solution, and both tannic acid and barium hydroxide respectively produced precipitates in aqueous solution of the starch. Excess of alcohol precipitated the starch from aqueous solution. Fehling's solution was not reduced by the substance, but after boiling the latter with dilute mineral acid Fehling's solution was readily reduced; on hydrolysing a portion of the substance with dilute sulphuric acid, removing the acid with barium hydroxide, and concentrating the filtered solution, crystals were obtained, the osazone of which melted at 204° C. The final product of hydrolysis is, therefore, dextrose.

The specific gravity of the air dried material (containing 15.78% of moisture) was 1.462, and that of the anhydrous material 1.583, the physical constant in both cases being taken in water; 0.8422 gram of the anhydrous material in 100 c.c. hydrochloric acid solution (prepared according to the method of C. J. Lintner, Z. ges. Brauw., 30, 109, 1910) gave optical rotation +1.7°; specific rotation $[\alpha]_D$ 201.8°

Microscopical Examination.

A minute portion of the substance was mounted in dilute glycerol and examined microscopically. It was seen to consist of corpuscles fairly uniform in size, ranging from approximately 8 to 20 micro-millimetres in diameter, and oval or polyhedral in shape. Treatment with a very dilute solution of iodine enabled the hilum to be seen as a dot or crack in the centre of the granule, but no concentric

rings were visible; no change in the appearance of the corpuscles was apparent when viewed by means of polarised light. Microscopically the corpuscles somewhat resemble those of rice or maize starch. (Plate XIX.)

The examination described above conclusively proves the insoluble material to be starch.

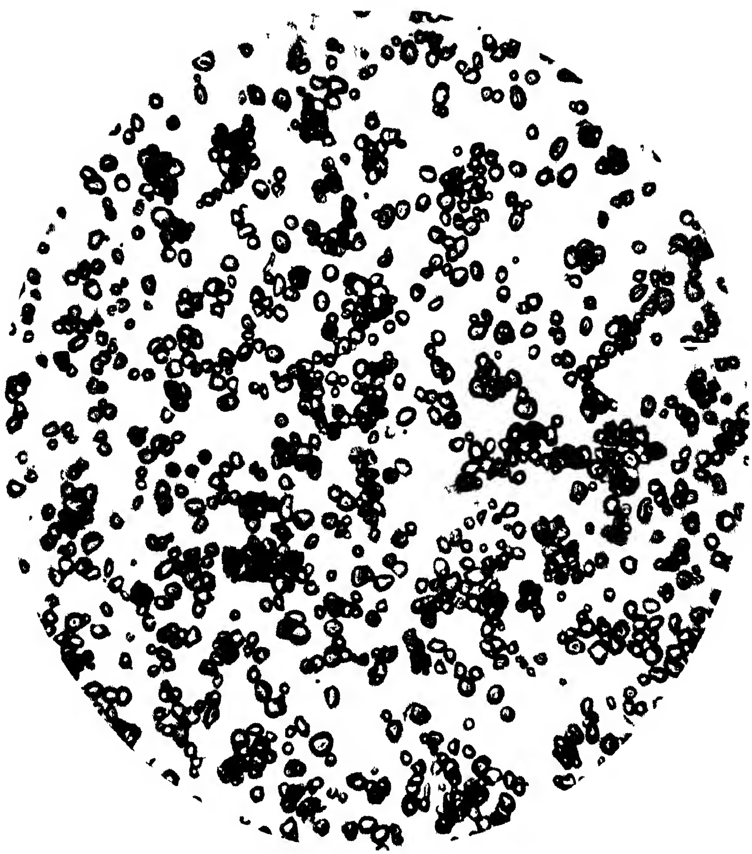
Chemical Estimation of the Starch Content of the Meal, and of the purity of the Separated Starch.

The methods employed for estimating the purity of the separated starch were (1) the Direct Acid Conversion method, and (2) the Diastase method. The former is applicable only in the absence of other carbohydrates which yield reducing sugars on hydrolysis. The estimation of the percentage of starch present in the meal was therefore carried out according to the Diastase method only, since other carbohydrates capable of being converted into reducing sugars were present.

Direct Acid Conversion method.—The air dried starch was treated with hydrochloric acid in the manner described by Leach, "Food Inspection and Analysis," p. 283, 1904. Three grams of starch gave on hydrolysis 2.758 grams of dextrose, the latter being determined by the Defren-O'Sullivan method (Leach, p. 594). Calculating from the above result, the starch content was 82.7%; the moisture content was 16.1%, and the ash on ignition 1.16%, making a total of 100%.

Diastase method.—The estimation of starch by this method was carried out both on the fat-free meal and on the separated starch. The procedure followed was that described by Leach, p. 284, freshly prepared malt extract being employed.

Starch in air dried fat-free meal (containing 13.39% moisture).—Three grams gave, on hydrolysis, 2.2871 grams of dextrose, equivalent to 68.61% starch. Calculated on the original air dried meal, the starch content was 66.4%.



"Bunya Bunya" starch. × 130.

Purity of separated starch.—Three grams of air dried starch gave, on hydrolysis, 2.7554 grams of dextrose, equivalent to 82.66% of starch; the moisture content was 16.08%, and the ash on ignition 1.16%, making a total of 99.9%. This result agrees very closely with that obtained by the Direct Acid Conversion method.

Summary.

The results of the investigation to date are summarised as follows, the percentages being calculated on the air dried meal:—

Fat	2.60
Matter soluble in cold water (dextrin)	7.72
Starch .. .. .. (a) 65.83, (b)	66.49
Crude fibre, etc.	7.93
Moisture	13.82
Ash	2.12

(a) starch separated from meal by mechanical means.

(b) starch determined in meal by chemical means (Diastase method).

The quantity of starch obtainable from the kernel compares favourably with the yields obtained from some commercial sources of starch, and providing that the seeds could be collected without difficulty, the commercial production of starch from this source is a possibility.

In conclusion, I have to thank Mr. A. R. Penfold, F.A.C.I., F.C.S., Economic Chemist, for advice and assistance in this investigation. To Mr. T. C. Roughley, Economic Zoologist, I am much indebted for the photomicrograph of the starch corpuscles. My thanks are also due to Mr. F. O'Donnell, Laboratory Assistant, for preparing the meal for examination.

NOTES ON THE PETROLOGY OF THE PROSPECT INTRUSION, WITH SPECIAL REFERENCE TO THE GENESIS OF THE SO-CALLED SECONDARY MINERALS.

By W. R. BROWNE, D.Sc.,

Assistant-Professor of Geology, University of Sydney.

(Read before the Royal Society of N.S. Wales, Dec. 3, 1924.)

Introductory.

A very full account of the geology and petrography of the Prospect intrusion was given in 1911 by Messrs. Jevons, Jensen, Taylor and Sussmilch[(1)], which was followed in the next year by a discussion of the differentiation phenomena exhibited by the rock-mass.[(2)] The intrusion is apparently somewhat in the nature of a laccolite or "dish-shaped sheet," probably about 300 feet in thickness, and while in general of basic composition, varies from place to place as regards both texture and the relative proportions of the constituent minerals. The mass contains two large segregation veins, composed partly of a coarser or pegmatitic phase of the rock, with conspicuously idiomorphic felspars, and partly of a finer-grained or aplitic phase, very rich in alkali felspar, and with only very minor proportions of ferro-magnesian constituents.

For the main mass of the rock the principal primary minerals are basic plagioclase, titaniferous augite, ilmenite, olivine, biotite and apatite, all of which are undoubtedly primary. In addition to these analcite, chlorite and serpentine are pretty constantly present, while carbonates, leucoxene and kaolin are frequent, and natrolite and stilbite have been found. All these are regarded by Jevons and his co-authors as secondary minerals, and a special section of their paper is devoted to the discussion of the

origin of the analcite, which had previously been regarded as primary by Mr. G. W. Card.(8) The conclusion eventually reached is that the evidence, on the whole, points to the analcite being secondary.

This mineral is recorded as occurring in all the specimens examined from the main mass, forming up to 4.9% of the rock by weight, but falling as low as 0.2% in the fine-grained marginal facies of the intrusion. It is likewise mentioned as a constant constituent of the segregation veins, both pegmatitic and aplitic.

The present writer has had a number of opportunities of studying the Prospect intrusion in the field, and has examined a number of thin sections of specimens from various parts of the rock-mass; as a result he feels convinced that the analcite, together with the other so-called secondary minerals, is really of magmatic origin.

Mode of Occurrence of the so-called Secondary Minerals.

(1) *Analcite* occurs in three different ways: (*a*) as an interstitial filling, occupying the angular spaces between the ordinary primary minerals of the rock, sometimes enclosing them partially or completely, and in general behaving like the latest mineral to crystallize from the magma; (*b*) as a replacement mineral, often decomposed, developed along cracks and cleavage-planes in the felspar; (*c*) as a filling of veins and vughs, the former cutting irregularly through the rock-mass, the latter occurring mainly in the pegmatitic and aplitic veins: in these cases the analcite is often well crystallised with characteristic icositetrahedral habit, and may be associated with other substances like chlorite, prehnite and calcite. The interstitial analcite often shows feeble birefringence and in places is turbid through decomposition.*

* The author is unable to agree with Jevons and his coauthors that this turbidity is due to the presence of minute inclusions.

(2) *Chlorite* occurs either in interstitial patches of radiating fibres moulded on augite and felspar, or irregularly replacing felspar and augite. It is also in places found in close association with the interstitial analcite, lining the interstices, forming a mantle or investment around the included crystals, or as little globular or rosette-shaped aggregates apparently enclosed in the analcite.

A chlorite-like mineral has been found forming the central parts of natrolite spherulites and a mineral probably of the nature of chlinochlore occurs in veins associated with calcite.

(3) *Serpentine* occurs along cracks in olivine or else completely pseudomorphing this mineral. It is the green pleochroic laminated variety with fairly high birefringence and straight extinction, which results from the alteration of a ferriferous olivine, and which, on oxidation, gives the brown substance called iddingsite. Elsewhere the olivine has been replaced by carbonates.

(4) *Natrolite* appears partly in vughs and partly on the faces of joint-planes in the rock-mass; it has likewise been noted as an interstitial filling and as a replacement of plagioclase. *Stilbite* has been noted by Jevons and his co-authors as an interstitial mineral, and something resembling it also occurs in cavities.

Prehnite is an extremely common constituent of veins and vughs, and in a thin section of a specimen from a pegmatitic segregation vein it appears in radiating crystal groups partially replacing felspar.

Pectolite was first identified by Mr. G. W. Card in a specimen collected by Mr. Arthur Combe[(4)]; other examples have since been found as vugh-fillings.

(5) *Calcite* is a very common mineral in veins and vughs, generally occupying the central portions of cavities

when associated with prehnite, or with analcite or other zeolites. It has also been observed playing an interstitial *rôle* in the pegmatitic phase of the rock, associated with chlorite; and occasionally it has been noticed partially replacing felspar and augite. A curious occurrence of the calcite in slender, rod-like forms enclosed in analcite, appears to result from the replacement of apatite. In one place calcite seems to be partially replacing analcite.

(6) It might be mentioned here that *pyrites* occurs associated with massive calcite in veinlets cutting through the aplite, and also in vughs sprinkled over the crystal faces of nail-head spar.

There are certain features in connection with the occurrence of these and other minerals of the rock which must have a certain significance. In the marginal facies of the rock felspar, augite and iron ore are quite fresh and free from alteration, the analcite percentage is low, and calcite, chlorite and zeolites are practically absent; in some of the finer-grained phases olivine is perfectly fresh, though somewhat cracked, in others it has changed to serpentine.

When the coarser or normal facies are examined, however, we find felspar being replaced by analcite, calcite, zeolites and chlorite, ilmenite changing to leucoxene, and interstitial analcite and chlorite occurring abundantly. But it is in the segregation veins—pegmatites and aplites—that the alteration culminates; olivine, of course, is absent from these, but the kaolinization of the felspars is very heavy, the interstitial and vugh-filling analcite and calcite are very conspicuous, and chlorite is also prominent. It is here, too, that the replacement of felspar by prehnite occurs, while the ilmenite is much leucoxenized and little granules of derived sphene make their appearance.

Jevons and his co-authors record the occurrence of both labradorite and albite, as well as orthoclase, in the peg-

matite. The present writer has been unable definitely to identify the potash felspar, but in the pegmatite, as well as in the normal rock, albite appears in thin section more like an alteration product, due to the albitization of labradorite, than an original mineral. Indeed the characteristic irregular patchy alteration to albite may in some cases be observed in a labradorite crystal. Mostly, however, the felspar is so much altered to analcite or kaolin that accurate observations are impossible.

Strangely enough, through all these changes the augite remains wonderfully fresh and relatively unaltered. True it is often much cracked, and a certain amount of chlorite, and occasionally calcite, have developed in the cracks, but the alteration is always much less than in the other minerals of the rock. Incidentally, the boundaries of the mineral against analcite are perfectly sharp, and there is no sign of the development of a rim of aegyrine-augite, such as was found by Tyrrell in the teschenite of the Lugar sill.[5]

Origin of the so-called Secondary Minerals.

Much has been written on the question of the primary nature of analcite. The matter was evidently being very much discussed at the time the original paper on the Prospect intrusion was written, and the authors of that paper, examining the rock with a full consciousness of the debated nature of the matter, arrived at the conclusion that in this instance the mineral was secondary, and that in particular the interstitial patches of it were to be explained as due to the complete replacement of original felspars.

But a large body of evidence has accumulated going to show that much at all events of the analcite in the teschenites and other analcitic rocks behaves as a primary mineral. It is unnecessary here to trace the history of petrological

thought in connection with this question, which has been discussed by a number of writers, including Dr. A. Scott(6), who also gives a fairly extensive bibliography of the subject. The matter has been put very clearly by Tyrrell (5), in dealing with the Lugar teschenite; he points out that the interstitial analcite represents the solidification of a final magmatic residuum which, before crystallizing, has attacked and partially replaced some of the other constituents. The same conception of the dual *rôle* of analcite is evidently shared by Flett (7), Bailey and Grabham (8), and Bailey (9, 10).

But this process of analcitization is only one phase of the activities of the magmatic residuum, which during the latest stages of the crystallization has also, according to various authorities, been responsible, among other things, for the albitization of lime-soda felspars, the serpentinization of olivine, and the deposition of a number of interstitial and vesicle-filling minerals including albite, chlorite, various zeolites and allied minerals, and calcite. The work of McLintock on the zeolites of the basic lavas of Ben More, Mull, is of interest in this connection (11).

It appears to be considered by some authors that the alterations indicated by albitization, analcitization and serpentinization occur immediately after consolidation of the rock as a whole, while by others the substitution is regarded as having taken place before the final crystallization in the interstices of the mineral network forming the partially consolidated rock. Observations on certain New South Wales rocks would seem to show that the process of substitution may sometimes take place when an appreciable amount of the magma is still liquid, but that in other cases the alteration has been entirely a post-consolidation process.

It seems advisable that some term should be used to express the conditions prevailing from the time when the magmatic residuum first attacks the earlier-formed minerals until the time of the final consolidation of the rock, that is, after the paulo-post processes have been completed, and some common term is likewise needed under which to group the minerals formed during this period, for, as has often been pointed out, they are not truly secondary, since they have not been produced as the result of weathering or other extraneous processes, and at the same time they are not the original crystallizations from the magma, but in many cases represent the result of alteration of original minerals.

Of course it is known, mainly as the result of the investigations by the chemists of the Geophysical Laboratory of Washington, that reactions may be more or less continuously going on in the crystallizing magma between the solid and liquid phases, resulting in the partial or complete resorption of the earliest crystals and the substitution of others in equilibrium with the changed conditions: still the changes now under discussion only occur in the latest stages of solidification, which might perhaps for purposes of convenience receive some special designation, although it is recognised that there is no break in the continuity of the process of crystallization. This designation would have to be applicable (1) to the stage or period of magmatic crystallization whose inception is marked by the commencement of corrosive activity by the magmatic residuum, (2) as a general term to the processes of solution and deposition at work during this period, and (3) to the minerals produced from the magmatic residuum as the result of simple deposition in veins, vughs and vesicles, or of interaction with pre-existing minerals. Obviously such terms as "post-volcanic," "pneumatolytic," and "juven-

ile'' express the idea only in part and are therefore unsuitable. The very useful term "deuteric," coined by Sederholm (12) to indicate the metasomatic changes "which have taken place in direct continuation of the consolidation of the magma of the rock itself," is by definition restricted so as to express only one phase of the activity, but might perhaps be widened in meaning sufficiently to serve the present purpose, which it would do most admirably. Otherwise the term "late-magmatic" might perform the threefold function indicated above.

In the case of the Prospect intrusion the writer is strongly of the opinion that the interstitial analcite is an original crystallization, and not a replacement product, as contended by Jevons and his co-authors: the sharp boundaries against felspar and augite, the inclusions of apatite and other primary minerals, and the general relations and behaviour of the analcite, which are not unlike those of orthoclase in a monzonite, all convey the impression of a mineral which was last to crystallize from the magma.

Indeed, one might go further and attribute most of the alterations of the normal rock to deuteric processes, for the freshness of the fine-grained selvage of the intrusion and the tendency for the maximum alteration to occur in and about the segregation veins argue against the meteoric origin of the solutions, and in favour of their magmatic nature, since percolating meteoric solutions would affect the outer envelope of the rock-mass as well as the interior, and on the other hand magmatic alteration would be greatest where and when there was the maximum concentration of residual magma or magmatic solutions.

The fact, too, of the interstitial spaces between the primary minerals having been lined with chlorite before being filled with analcite would *a priori* indicate a deuteric

origin for the former mineral. Bailey and Tyrrell [5], consider that the chlorite or serpentine associated with interstitial analcite may be due to alteration of the latter, but there seems no reason to put this rather forced interpretation on the phenomena, in the Prospect occurrence at all events, where the zeolite has all the appearance of having been deposited on top of the chlorite, and the little rosettes of chlorite apparently completely isolated in analcite probably represent sections through investments wrapping round the ends of minerals, like apatite, included in, or projecting into the analcite.

The alteration of olivine, it is considered by Bailey and Grabham and by Tyrrell, may be a deuteric process, and the observations of the present writer go to show that the change to the green strongly birefringent variety of serpentine in particular is common in basic rocks which have been subject to the action of residual magma or magmatic solutions.

The following are the phenomena which are considered as probably deuteric in the Prospect intrusion:

(a) Replacement of labradorite by albite.
(b) Change of olivine to serpentine.
(c) Replacement of felspar by analcite, natrolite, prehnite and chlorite (in some cases albitization may have preceded this later alteration).
(d) Interstitial deposition of chlorite, analcite, natrolite and calcite.
(e) Deposition in vughs and veins of chlorite, prehnite, analcite, natrolite, stilbite, pectolite and calcite.
(f) Change of felspar to kaolin, and
(g) Deposition of pyrites.

The order of formation of the various minerals it has been impossible to determine in every case, but a certain

amount of information has been obtained in regard to the matter.

Probably albitization was the first process, since in the crystallization of the aplitic segregation veins albite was first formed, analcite and chlorite acting as the interstitial filling. The alteration of olivine, and of augite too, was probably fairly early, since the chlorite lining the cavities was doubtless in part, at all events, derived from these minerals. It is rather puzzling in this connection to find that in the fine-grained marginal selvage of the rock there has been no albitization, and yet that olivine has been changed into serpentine and interstitial analcite has been deposited.

Chlorite was deposited after albite and before analcite. The quantity of this mineral present makes one wonder whether it is entirely derived from the alteration of the primary ferro-magnesian minerals or whether it is the normal crystallization product of the ferro-magnesian constituents of the magma when magmatic water is in excess and temperatures are low, just as in similar circumstances the crystallization of analcite and other zeolites supersedes that of albite.

The deposition of prehnite preceded that of analcite, as the latter is found encrusting the former in veins. The relative order of deposition of analcite, natrolite, stilbite and pectolite it is impossible to deduce, as they have not been found in contact. Experiment, however, has shown that natrolite forms at lower temperatures than analcite (Doelter [18]), and the fact that the former mineral is found mainly in cracks and joint-fissures through the Prospect intrusion, whereas analcite has a much greater variety of occurrence, would point to the latter being the earlier mineral of the two. If the order of deposition was one of increasing hydration, as determined by McLintock for the

zeolites of the Tertiary lavas of Mull (11, p. 24), then it would be: prehnite, analcite, natrolite, stilbite. Except for pyrites, calcite generally appears to be the last mineral to be deposited, occupying the central portions of veins and vughs. It has also been noted occurring interstitially, but whether as the result of primary deposition or as a replacement of analcite it would be difficult to say.

In certain vughs calcite appears bedded on prehnite, and is itself encrusted by a further deposit of this mineral. Inspection of hand specimens does not reveal whether the calcite is really a primary deposit between two layers of prehnite or a partial replacement of the latter.

The position of the formation of kaolin from the felspars in the sequence of events it would be hard to determine. There is no internal evidence in regard to the matter, except that the albite of the aplite is kaolinized; as, however, kaolinization is believed to be accomplished by carbonated waters, it is possible that in this instance it preceded the deposition of the calcite, the lime for which may indeed have been derived from the plagioclase partly during albitization and partly during kaolinization.

Cooling-History of the Intrusion.

Jevons and his co-authors have traced the probable cooling-history of the intrusion, showing how, immediately following of the injection of the magma into the cold country rock, there was the formation of a chilled selvage, whose composition therefore represents approximately that of the original magma: inside the non-conducting envelope thus formed cooling proceeded slowly, permitting of a certain amount of gravitative settling during crystallization. Later on shrinkage cracks appeared, into which the residual magma oözed, forming the pegmatitic and finally

the aplitic veins*. This very satisfying explanation of the phenomena is essentially the same as that put forward independently by Daly in the same year to account for the variation in the Square Butte and other intrusions [14].

If the gravitative theory is correct we might expect to find an olivine-rich "ledge" some distance above the base of the intrusion, such as has been recorded by J. V. Lewis in the case of the Palisade diabase [15], or to find the normal rock grading downwards into a picrite or peridotite, as in the Lugar sill. Unfortunately neither tilting nor valley erosion has given us a complete section through the intrusion, and quarrying operations are not likely, in this generation at least, to extend downwards sufficiently far to permit of the testing of this possible corollary to the gravitational theory.

But the cooling-history of the intrusion does not stop with the formation of the aplitic veins: it would appear that at this time perhaps not more than 90% of the mass was crystalline, the interstices being filled with strongly sodic residual magma containing dissolved carbon dioxide. The deuteric period was now entered upon, commencing with the albitization of basic felspar and the alteration of olivine, then the deposition in interstices, vughs and veins, of chlorite, with the attack of the felspars and the deposition of analcite, the other zeolites and allied minerals, and calcite.

It is obvious that much work yet remains to be done in regard to the exact sequence of the events of this deuteric period. It is not known, for example, when the corrosion of the felspars with the formation of analcite commenced, and whether the lime for the prehnite, stilbite, pectolite and calcite was originally present in the magmatic residuum

* The separation of an acid and alkaline mother-liquor from the residual magna, as postulated by Jevons, seems unnecessary.

or was derived from the corrosion of the felspars. These and other matters would well repay more detailed field and laboratory study.

Nomenclature of the Rocks.

In the paper by Jevons *et al.* the rock of the Prospect intrusion, previously known as a dolerite, was given the general name of essexite, on the ground that it represented the basic differentiate of a foyaitic-theralitic magma.

In view of their opinion as to the secondary nature of the analcite it was natural enough that this mineral should be ignored by them when considering the question of nomenclature. But seeing that the analcite may be regarded as primary, and that this mineral is now recognised as of definite significance in rock classification and nomenclature, a reconsideration of the matter would seem desirable.

	I.	II.	III.	IV.	V.	VI.
SiO_2	41.05	43.06	46.26	45.71	43.94	48.18
Al_2O_3	12.27	16.31	13.36	15.23	14.03	11.80
Fe_2O_3	6.39	5.40	2.34	2.84	1.95	9.79
FeO	11.07	7.61	10.53	6.93	11.65	5.90
MgO	6.38	5.49	8.87	8.11	10.46	6.05
CaO	10.96	9.37	9.18	7.34	8.99	7.50
Na_2O	2.43	3.12	3.27	3.96	2.68	3.46
K_2O	0.53	1.07	1.23	1.31	0.33	1.57
H_2O+	3.58	2.93	2.08	4.70	2.31	3.20
H_2O-	0.44	1.16	0.15	1.54	0.85	
CO_2	0.03	1.36	0.06	—	0.16	0.71
TiO_2	4.39	2.46	1.78	1.64	2.45	—
P_2O_5	0.19	0.32	0.42	0.47	0.20	0.49
S (FeS_2)	0.35	0.26	abs.	S 0.08	0.10*	—
MnO	0.17	0.23	0.12	0.54	0.32	—

* $Fe_n S_{n+1}$

I, II, and III. Prospect Rock. Quoted from paper by Jevons *et al.* This Journal, 1911, vol. XLV, p. 504.

IV. Teschenite from Blackburn, Linlithgowshire. Quoted from Mem. Geol. Surv. Scotland, 1910, "The Geology of the Neighbourhood of Edinburgh," p. 299.

V. Olivine—Analcite—Dolerite (Crinanite). Quoted from Mem. Geol. Surv. Scotland, 1910, "The Geology of East Lothian," p. 46.

VI. Teschenite from Boguschowitz, Silesia. Quoted from Rosenbusch: Gesteinslehre, p. 176.

Chemically the rock is closely allied to the analcite-dolerites, more so perhaps than to the essexites, as may be seen from the analyses quoted above, while the mineral constitution and the mineral characteristics are very similar to those recorded for various examples of teschenites. But according to Holmes [16], the name of teschenite is preferably reserved for those analcite-dolerites containing a soda-pyroxene or a soda-amphibole or both. Now the Prospect rock, in its typical facies at all events, contains none of the former, and although a very little barkevikitic hornblende has been detected in one slide, still this mineral is typically absent.

It is considered, therefore, that the rock is best termed an olivine-analcite-dolerite, and this name is here proposed as a substitute for that of essexite, as expressing more accurately the character of the rock.

LIST OF REFERENCES.

1 Jour. Roy. Soc. N.S.W., 1911, Vol. 45, pp. 445-553.

2 Jour. Roy. Soc. N.S.W., 1912, Vol. 46, pp. 111-138.

[3] Rec. Geol. Surv. N.S.W., 1902, Vol. 7, p. 101.

[4] Analysis in Ann. Rept. Dept. Mines N.S.W., 1919, p. 185.

[5] Quart. Jour. Geol. Soc., 1916, Vol. 72, pp. 100-101.

[6] Trans. Geol. Soc. Glasgow, 1915-16, Vol. 16, Part 1, pp. 34-45.

[7] Mem. Geol. Surv. Scotland, "The Geology of Edinburgh," 1910, pp. 295-6.

[8] Geol. Mag., 1909, Vol. 6, p. 256.

[9] Mem. Geol. Surv. Scotland, "The Geology of East Lothian," 1910, pp. 114-115.

[10] Mem. Geol. Surv. Scotland, "The Geology of the Glasgow District," 1911, p. 133.

[11] Trans. Roy. Soc. Edinburgh, 1915, Vol. 51, pp. 1-33.

[12] Bull. Comm. Géol. Finlande, 1916, No. 48, p. 142.

[13] Tschermak's Min. und Petr. Mitt., 1906, Band 25, pp. 79-112.

[14] Geol. Surv. Canada, Memoir No. 38, 1912.

[15] Ann. Rept. State Geologist of New Jersey for 1907.

[16] The Nomenclature of Petrology, p. 30.

A FURTHER CONTRIBUTION TO THE KNOWLEDGE OF THE SILKY OAKS.

By M. B. WELCH, B.Sc., A.I.C.

Economic Botanist, Technological Museum.

(With Plates XVI.-XVIII.)

(Read before the Royal Society of N.S. Wales, December 3, 1924.)

In 1918, owing to the confusion existing in the nomenclature of certain timbers belonging to the Natural Order Proteaceae, known as Silky Oaks, R. T. Baker dealt very fully with the anatomical and other features of five species in a paper read before this Society*. The woods described were:—*Grevillea robusta,* A. Cunn; *G. Hilliana,* F.v.M.; *Embothrium Wickhami,* F.v.M.; *Cardwellia sublimis,* F.v.M.; and *Orites excelsa,* R.Br. In this paper some additional woods which have come to hand, and sometimes classed as Silky Oaks are described. These are: *Carnarvonia araliaefolia,* F.v.M., Atherton Red Oak; *Grevillea gibbosa,* R.Br., Rose Oak; *Darlingia spectatissima,* F.v.M., Brown Oak; *Musgravea stenostachya,* F.v.M., Brown Oak, and *Stenocarpus sinuatus,* Endl., White Silky Oak. This latter wood is more usually known in New South Wales as Fire-Tree.

In common with the majority of Proteaceous woods, all these possess more or less broad multiseriate rays, which when cut radially (i.e., on the quarter), give a characteristic "oak" figure, and differ from the majority of true Oaks, *Quercus,* spp., in that they are diffuse porous, and therefore when cut tangentially do not show the "ash"

* R. T. Baker. On the Technology and Anatomy of some Silky Oak Timbers. Proc. Royal Soc., N.S.W., 1918, Vol. LII., pp. 362-376.

like figure found in the oaks when so cut, or to a lesser extent in the so-called "Tasmanian Oak," *Eucalyptus Delegatensis*, R.T.B., and allied species. The rays in the Silky Oaks are numerous, and on a tangential surface appear as lenticular areas of softer tissue, darker in colour than the fibre zones separating them.

Besides the Proteaceae spp. *(supra.)*, there are several other Australian woods to which the common name "oak" is applied. (1) "Brown Oak" is sometimes used to designate two species of *Tarrietia,* namely *T. argyrodendron,* Benth, "Crow's Foot Elm," and its varieties, and also *T. actinophylla,* C. Moore, "Stave-Wood." These belong to the Natural Order Sterculiaceae, and possess much narrower rays than the Proteaceous species. The rays are also much shorter in vertical height in the former woods. (2) The "She-Oaks," *Casuarina* spp., are hard, heavy, close-grained woods with very large multiseriate rays measuring up to 3 mm. in width and 100 mm. or more in height. A notable exception is the Belah *C. Cambagei.* (3) The Tasmanian Oak is a Eucalypt, the rays being principally uniseriate and inconspicuous, and when quarter-cut naturally does not show any "oak" figure.

It is proposed to describe in some detail the microscopical features of the woods, though under the heading of "macroscopical characters," are features which can be recognised with a pocket lens, or even with the naked eye.

The Queensland specimens were kindly supplied by the Director, Queensland Forest Service, Brisbane.

Stenocarpus sinuatus, Endl.

Fire Tree, White Silky Oak (Plate XVI., Fig. 1).

A pale yellow to light brownish coloured wood, of medium weight (about 40 lbs. per cubic ft.), and hardness.

It possesses moderate lustre, polishes well, and is suitable for interior panelling or joinery, cabinet work, etc. It occurs as a large tree in the brushes of northern New South Wales, extending into Queensland.

Macroscopical characters.—Pores of moderate size, few in number, usually single or in small groups, very rarely in tangential rows. Soft tissue in very numerous, crowded, conspicuous, fine curved lines, concave side outward. Rays conspicuous on end section, fairly even in size and spacing. Fine rays often present between larger ones.

Microscopical details.—Vessels with numerous bordered pits, end perforation simple, $60\mu - 225\mu$ in diameter, walls about 5μ in thickness, end projections prominent; a yellowish brown deposit often present; tyloses absent; average number per sq. mm.3, max. 5., min. 2. Tracheids up to $1{,}000\mu$ in length and 40μ in diameter. Wood fibres $1{,}000\mu - 2{,}250\mu$ in length, average diameter 35μ, moderately thick walled, pits small, bordered, not simple. Wood parenchyma cells $140\mu - 300\mu$ in length, $15\mu - 45\mu$ in width, cells not compressed radially, 1-4 cells wide in very numerous metatracheal bands, or vasicentric, a few cells scattered. Rays multiseriate, heterogenous, $100\mu - 400\mu$ in width, $1{,}000\mu - 5{,}000\mu$ in length, uniseriate rays not numerous, 1-6 cells deep, cells often with longest axis vertically directed.

Darlingia spectatissima, F.v.M.

Brown Oak, Chalagar (Plate XVI., Fig. 2).

A light brownish coloured wood, hard, close-grained, moderately heavy (weight per cubic ft. about 50 lbs.), with little lustre. "Wood tough, nicely marked, and should prove a useful timber for cooper and cabinet work." J. F. Bailey*. The tree is found on the northern coast

* J. F. Bailey, Report on Timber of Herberton District, September, 1899.

district of Queensland, "Rockingham Bay and Herberton district." F. M. Bailey†. A specimen in the Technological Museum supplied by the Queensland Forest Service is from Atherton.

Macroscopical characters.—Pores usually small, numerous, crowded, together with narrow bands of soft tissue, arranged in tangential curved rows with the concave side outward or single. Rays comparatively narrow in transverse section. Very fine radial lines of soft tissue easily visible between rays with a pocket lens (uniseriate rays).

Microscopical details.—Vessels with numerous small slit-like bordered pits, end perforation simple, $90\mu-225\mu$ in diameter, walls 5μ in thickness; a brown deposit rarely present; tyloses absent; number per sq. mm. 16, max. 18, min. 15. Tracheids with small bordered pits, about 600μ in length × 35μ in diameter. Wood fibres with semi-bordered pits, average diameter 30μ, length $1{,}200\mu-2{,}000\mu$ lumen often reduced to 1μ. Fibres show transition through libriform fibres to tracheids. Wood parenchyma with numerous simple pits, average 200μ × 25μ in diameter, as metatracheal bands 1-3 cells wide, or vasicentric. Rays multiseriate, $100\mu-450\mu$ in width, $1{,}000\mu-3{,}000\mu$ in length, cells very variable in size and shape, pitting simple, small rays usually uniseriate, rarely two cells wide, 1-12 cells deep, numerous.

GREVILLEA GIBBOSA, R.Br., Rose Oak.
(Plate XVII., Fig. 3.)

A fairly hard, dark reddish brown coloured timber of moderate weight (about 50 lbs. per cubic foot). "Wood dark brown, prettily marked, of a greasy nature which prevents it shining when polished." F. M. Bailey, *l.c.* A tree sometimes reduced to a shrub found in the coastal district of Queensland.

† F. M. Bailey, Queensland Flora, Vol. 4, 1901.

Macroscopical characters.—Pores crowded in tangential rows or in small groups or solitary, soft tissue not conspicuous, but occurring together with the pores in short more or less straight bands between the rays. Rays conspicuous on end section, lighter in colour than the other tissue.

Microscopical details.—Vessels with numerous small bordered pits, end perforation simple, $100\mu - 300\mu$ in diameter, walls about 4μ in thickness; often with a brown deposit; tyloses absent. Number per sq. mm. 9, max. 13, min. 7. Tracheids up to 600μ in length and 45μ in diameter. Wood fibres very thick walled, mean diameter 35μ, lumen often reduced to 2μ, pits small, bordered, not simple; $1{,}500\mu - 3{,}000\mu$ in length. Wood parenchyma, very numerous, large cells, comparatively thick walled, with simple pits, $200\mu - 450\mu$ in length and up to 60μ in diameter, chiefly present as metatracheal bands, also scattered or vasicentric. Rays multiseriate, heterogeneous, cells very variable in size and shape, pits simple; $100\mu - 450\mu$ in width, $1{,}000\mu - 3{,}000\mu$ in height. Uniseriate rays numerous, 1-12 cells high, rarely 2 cells wide.

Carnarvonia araliaefolia, F.v.M.

Atherton Red Oak, Red Oak, Niah.

(Plate XVII., Fig. 4: Plate XVIII., Fig. 5).

A reddish to reddish-brown coloured wood of medium weight (39-43 lbs. per cubic ft.) and hardness, with a slight lustre. Texture fairly open. F. M. Bailey, *l.c.*, describes the wood as being "of a red colour, firm, fine grained, useful for cabinet makers' and coopers' work." The tree is of moderate size and occurs in the northern coast district of Queensland.

Macroscopical characters.—Pores in short tangential rows, single or in small groups, rows rarely extending

right across space between rays. Soft tissue in numerous, crowded, narrow bands, rarely much curved, large rays prominent, fine rays not or scarcely visible.

Microscopical details.—Vessels with numerous small bordered pits, end perforation simple, end projection usually short, $75\mu - 225\mu$ in diameter, walls about 4μ in thickness; a brown deposit often present; tyloses absent; average number per sq. mm. 6, max. 9, min. 5. Tracheids with numerous small bordered pits, up to 750μ in length and 45μ in diameter. Wood fibres very thick walled, lumen often reduced to 2μ in diameter, average diameter 35μ, $1{,}500\mu - 3{,}000\mu$ in length; pits small, bordered. Wood parenchyma thick walled, with numerous simple pits, cells up to 300μ in length and 30μ in diameter, occurring in numerous metatracheal bands up to 6 cells in width, also scattered, vasicentric and in short radial rows. Rays multiseriate, heterogeneous up to 600μ in width and $5{,}000\mu$ in height, uniseriate rays absent.

MUSGRAVEA STENOSTACHYA, F.v.M.

Brown Oak (Plate XVIII., Fig. 6).

A brownish coloured timber of moderate weight (about 40 lbs. per cubic ft.) and hardness, "nicely marked, light and firm, a useful wood for both cooper and cabinet maker. Does not shrink or warp much in drying." (F. M. Bailey).

Macroscopical characters.—Pores of moderate size, in small groups, often single, rarely in tangential rows. Soft tissue in very fine numerous tangential lines. Rays fairly narrow, regular in size, much narrower than in *G. robusta* or *O. excelsa*, fine rays often present but inconspicuous.

Microscopical details.—Vessels with numerous small bordered pits, end perforation simple, $100\mu - 225\mu$ in diameter, walls about 6μ thick; a brownish deposit often

present; tyloses absent; average number per sq. mm. 8, max. 12, min. 6. Tracheids with numerous small bordered pits; irregular in shape, up to 1,200μ in length and 60μ in diameter. Wood fibres, 1,000μ – 2,250μ in length; average diameter 30μ; wall thickness about 10μ. Wood parenchyma present in numerous narrow metatracheal bands, usually not more than 2 cells wide, cells compressed radially, or vasicentric, a few cells scattered; average size 250μ by 45μ. Rays multiseriate, heterogeneous, with a tendency to become aggregate, 1,500μ – 5,000μ in length, and 100μ – 300μ wide. Uniseriate rays present, 1-12 cells high, cells often with longest axis vertically directed.

As the general characters of the following Silky Oaks were given fully by Baker, *l.c.*, only some of the principal microscopical features will be briefly described.

GREVILLEA ROBUSTA, A. Cunn.

Silky Oak.

A brownish coloured wood of medium weight (36-39 lbs. per cubic ft.), and hardness. Pores in groups, arranged more or less tangentially, but not in definite transverse rows between the rays as in *Orites excelsa;* brown deposit rarely present; tyloses absent; end perforation simple; mean diameter 150μ; average number per sq. mm. 12. Wood fibres moderately thick walled, mean diameter 18μ, arranged in zones alternating with broad curved bands of metatracheal parenchyma, concave outwards, up to 10 cells in width. Vasicentric and scattered parenchyma present. Rays multiseriate, diffuse, heterogeneous; large rays up to 700μ in breadth, 5,000μ in length. Uniseriate rays 1-10 cells high.

GREVILLEA HILLIANA, F.v.M.

Red Silky Oak.

A hard, heavy (about 62 lbs. per cubic ft.), dark reddish coloured timber. Pores small, single or in small groups,

not in tangential rows, a brown deposit often present; tyloses absent; end perforation simple; mean diameter 100μ; average number per sq. mm. 10. Wood fibres make up bulk of tissue, very thick walled, lumen often reduced to 2μ Wood parenchyma in narrow, metatracheal bands, 1-6, but usually not more than 3, cells wide, also vasicentric, not scattered. Rays multiseriate, heterogeneous, comparatively narrow, 150μ wide, up to 4,000μ in length, with a tendency to become diffuse. Uniseriate rays 1-20 cells high.

EMBOTHRIUM WICKHAMI, F.v.M.

Satin Silky Oak.

A soft, pinkish coloured wood with a very satiny lustre, light in weight (30-33 lbs. per cubic ft.). Pores single or in small groups, not in tangential bands, end perforation simple; a brown deposit often present; tyloses absent; mean diameter 180μ; average number per sq. mm. 5. Wood fibres large, average diameter 35μ, comparatively thin walled. Wood parenchyma vasicentric, metatracheal bands absent. Rays multiseriate, heterogeneous, with a tendency to become diffuse, prominent on account of brown deposit in cells, up to 300μ wide, 10 mm. in length. Uniseriate rays 1-12 cells high.

CARDWELLIA SUBLIMIS, F.v.M.

Bull Silky Oak.

A brownish coloured timber of moderate weight (36-39 lbs. per cubic ft.), and hardness. Pores large, up to 300μ in diameter, in tangential rows; pits slit-like; a brown deposit often present; tyloses absent; average number per sq. mm. 8. Wood fibres moderately thick walled, large, average diameter, 35μ. Wood parenchyma in very prominent metatracheal bands often equal in width to the fibre zones between, up to 12 cells wide, also vasicentric. Rays very

large, multiseriate, heterogeneous, up to 1,000μ in diameter and 12 mm. in height. Uniseriate rays not prominent 1-12 cells high, rarely becoming 2 cells wide.

Orites excelsa, R.Br.
Silky Oak.

A brownish coloured timber of moderate weight (37-40 lbs. per cubic ft.) and hardness, resembling superficially *G. robusta,* but differing in structure. Pores in very definite short, usually straight, tangential rows; brown deposit not common; tyloses absent; end perforation simple; average diameter 100μ; number per sq. mm. 18. Wood fibres thick walled. Wood parenchyma vasicentric, sometimes extended into short metatracheal bands. Rays multiseriate, heterogeneous, inclined to be diffuse, up to 450μ in width, and 9 mm. in height; uniseriate rays 1-10 cells high.

Alcoholic extracts were prepared from small quantities of the wood (2g. shavings boiled in 30c.c. EtOH.). These were tested for flavone by the method described by Kanehira*, the results, however, being negative. The following notes refer to the extracts:—

Grevillea robusta.—Colour light yellow brown, turbid, precipitate on adding water, little alteration in colour with ferric chloride or caustic potash.

Grevillea Hilliana.—Colour red brown, turbid, very turbid on adding water, slight fluorescence, very dark brownish green precipitate with $FeCl_3$.

Grevillea gibbosa.—Colour dark yellow brown, clear, slight fluorescence, no turbidity on adding water, brownish green coloration with $FeCl_3$.

Cardwellia sublimis.—Colour light yellow brown, clear, very slight fluorescence, slight turbidity on adding water, little alteration in colour with $FeCl_3$, or KOH.

*R. Kanehira, Anatomical Characters and Identification of Formosan Woods, Taihoku, 1921.

Orites excelsa.—Colour light yellow-brown, clear, no turbidity on adding water, thus differing markedly from *G. robusta,* darkening to olive-brown with $FeCl_3$.

Embothrium Wickhami.—Colour slightly pink, almost colourless, slightly turbid, turbid on adding water, very little alteration in colour on adding $FeCl_3$, but slight precipitate.

Carnarvonia araliaefolia.—Colour deep red brown, clear, slight turbidity on adding water, fluorescent, purplish with reflected light, brownish green precipitate with $FeCl_3$.

Darlingia spectatissima.—Colour yellow brown, darker than *Grevillea robusta* or *Cardwellia sublimis,* clear, no turbidity on adding water, brownish green coloration with $FeCl_3$.

Stenocarpus sinuatus.—Colour pale yellowish, clear, no turbidity on adding water, little alteration with $FeCl_3$

Musgravea stenostachya.—Almost colourless, *c.f.*, *O. excelsa,* clear, no turbidity on adding water, thus differing from *G. robusta,* little alteration with $FeCl_3$, yellow with KOH.

Alkannin showed an oily body, usually readily soluble in cold alcohol, to be present in all the species examined, but in very variable quantity. A maximum was found in *Grevillea robusta, G. Hilliana* and *Carnarvonia araliaefolia,* being present largely in the wood fibres and wood parenchyma and usually to a lesser extent in the ray cells, tracheids and vessels. A fairly large oil content was found in *Embothrium Wickhami,* and comparatively little in *Cardwellia sublimis, Darlingia spectatissima, Stenocarpus sinuatus, Orites excelsa, Musgravea stenostachya, Grevillea gibbosa.*

For convenience, the following key is based chiefly on macroscopical characters seen on end section:—

(a) Timber yellow to brown or pinkish brown.

(b) Rays narrow, conspicuous, darker than other tissue on end section, wood pink with satiny lustre; tangential bands of soft tissue absent; pores large, single, or in small groups = *Embothrium Wickhami.*

(b_1) Rays lighter than other tissue on end section; wood yellow to brown.

(c) Rays large, up to 1 mm. in diameter and 12 mm. in height; pores large, in tangential rows; very conspicuous alternating zones of fibres and soft tissue = *Cardwellia sublimis.*

(c_1) Rays of medium size, seldom more than 0.5 mm. in width or more than 6 mm. in height.

(d) Wood pale yellow in colour; pores few, usually solitary or in groups of two or three; conspicuous narrow crowded, curved, tangential bands of soft tissue = *Stenocarpus sinuatus.*

(d_1) Wood brownish in colour.

(e) Wood hard, comparatively close grained and heavy; pores small, numerous, crowded; curved tangential bands of soft tissue and pores present; fine conspicuous, radial lines between broad rays = *Darlingia spectatissima.*

(e_1) Wood of medium weight and hardness, comparatively open grained.

(f) Pores in usually straight short tangential rows between rays, medium sized to small; soft tissue bands narrow = *Orites excelsa.*

(f_1) Pores and soft tissue in broad curved bands between rays; pores medium sized = *Grevillea robusta.*

(f_2) Pores solitary or in small groups, rarely in tangential rows; soft tissue inconspicuous, visible only with pocket lens as numerous fine tangential lines = *Musgravea stenostachya.*

(a_1) Wood, reddish to dark reddish brown in colour.

(g) Wood, very heavy and hard; pores small, single, or in small groups; soft tissue in narrow bands; rays narrow = *Grevillea Hilliana.*

(g_1) Wood of medium weight and hardness.

(h) Wood, dark reddish brown in colour; pores large, in short, tangential rows or in small groups; soft tissue not prominent; rays narrow, under 0.25 mm. = *Grevillea gibbosa.*

(h_1) Wood, reddish in colour; pores medium sized, soft tissue conspicuous in numerous fine curved tangential bands; rays often over 0.5 mm. in width = *Carnarvonia araliaefolia.*

EXPLANATION OF PLATES.

(Plate XVI.)

Fig. 1.—*Stenocarpus sinuatus* Endl. Transverse section of wood shewing scattered, usually single, pores. Numerous tangential metatracheal parenchyma bands, multiseriate rays present and comparative absence of uniseriate rays. × 32.

Fig. 2.—*Darlingia spectatissima* F.v.M. Transverse section of wood shewing numerous, comparatively small pores in more or less tangential rows. Vasicentric wood parenchyma, narrow multiseriate rays and uniseriate rays prominent. × 32.

(Plate XVII.)

Fig. 3.—*Grevillea gibbosa* R. Br. Transverse section of wood shewing pores in short tangential rows, and wood parenchyma often in broad metatracheal bands. The multiseriate ray cells often fusiform. Uniseriate rays not conspicuous. × 32.

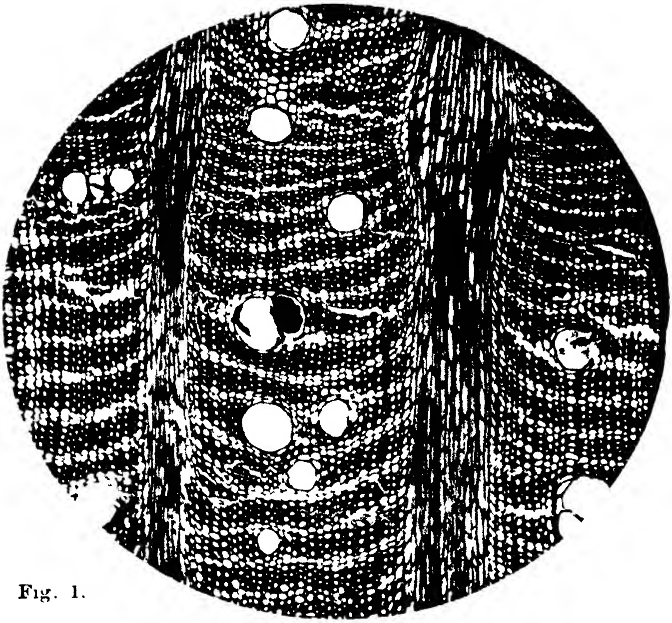


Fig. 1.

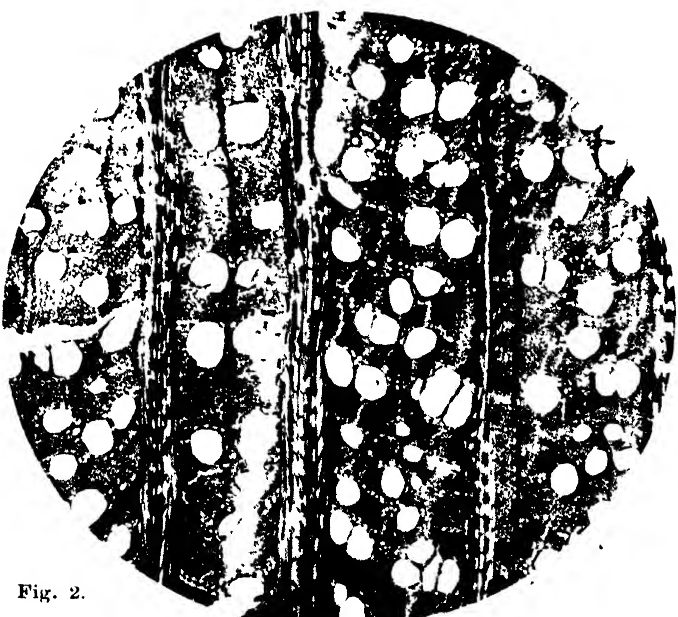


Fig. 2.

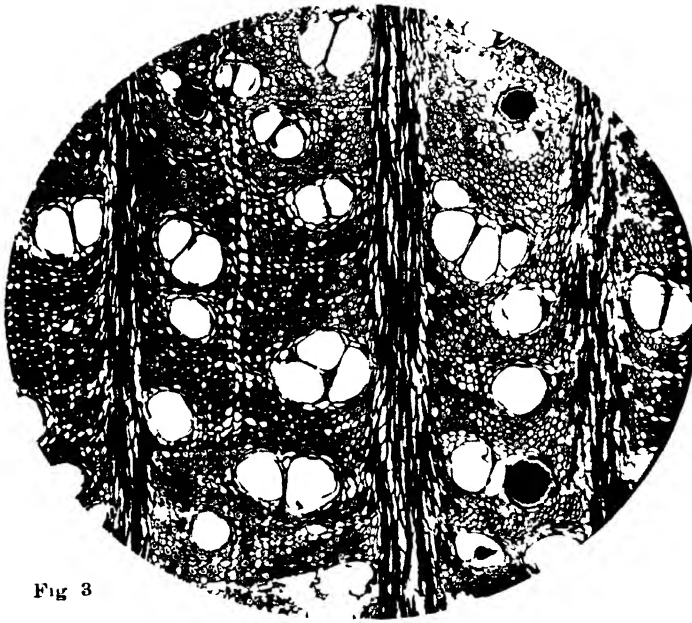


Fig 3

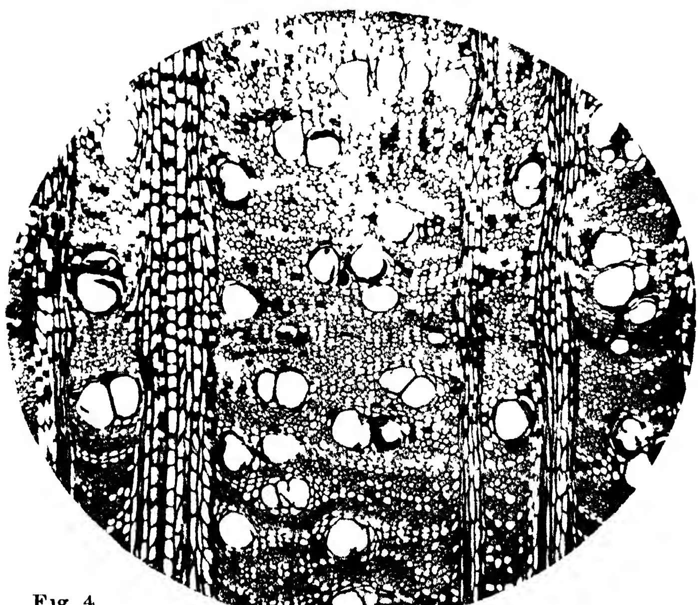


Fig 4

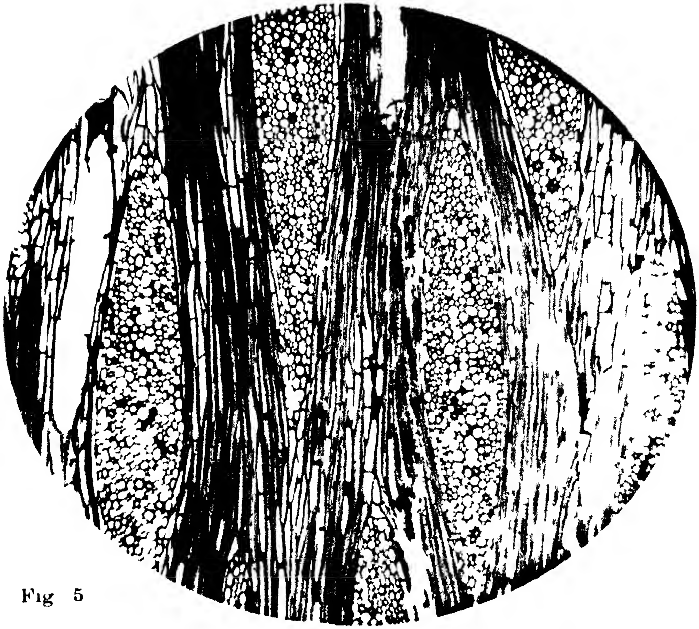


Fig 5

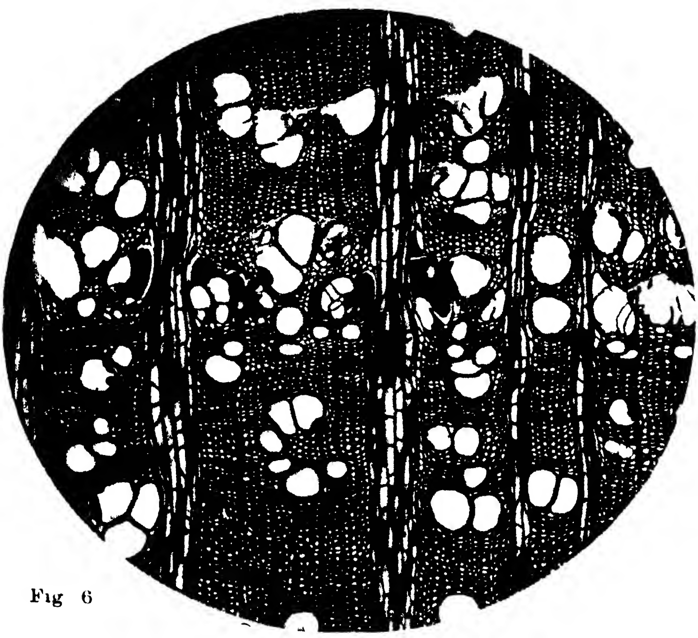


Fig 6

Fig. 4.—*Carnarvonia araliaefolia* F.v.M. Tranverse section of wood shewing pores in short tangential rows or single. There is a very marked development of wood parenchyma, chiefly in almost straight metatracheal rows. Uniseriate rays absent. $\times$ 32.

(Plate XVIII.)

Fig. 5.—*Carnarvonia araliaefolia* F.v.M. Tangential section of wood shewing more or less typical Proteaceous structure. Near the right is portion of a metatracheal band of wood parenchyma with elongated, pitted cells. Multiseriate heterogeneous rays conspicuous. $\times$ 32.

Fig. 6.—*Musgravea stenostachya* F.v.M. Transverse section of wood, shewing pores usually scattered; in the centre of the field they are somewhat crowded, apparently due to injury. Numerous narrow metatracheal bands of wood parenchyma present. Multiseriate rays narrow becoming diffuse. Uniseriate rays present. $\times$ 32.

KAMILAROI AND WHITE.

A STUDY OF RACIAL MIXTURE IN NEW SOUTH WALES.

By PROFESSOR GRIFFITH TAYLOR, B.A., D.Sc., B.E.,
and
F. JARDINE, B.Sc.

[With Plates XX.-XXVI and eight Text Figures.]

(Read before the Royal Society of N.S. Wales, Dec. 3, 1924.)

CONTENTS.

PART I.—SOCIOLOGY.

(a) Introduction.

The labours of Etheridge, Fraser, Matthews and others in the past have placed on record many important details with regard to the culture and language of the aborigines of New South Wales. But in recent years there has been practically no work done in this State, though the field left unworked is large and the opportunity for research will have passed away in relatively a very short time.

The aborigines of eastern New South Wales were soon brought into contact with white civilisation. Their old culture disappeared rapidly, and by the time that the scientific study of ethnology began in Australia, the investigators naturally devoted themselves to the less contaminated races of the interior. In consequence we know less about many of our east coastal tribes than of those dwelling in the arid regions of Central Australia.

There are, however, two important aspects of Anthropology in which valuable research is still possible among the relics of our eastern aborigines. It is not too late to make a complete anthropometric survey both of the fullbloods and of the hybrids (with the white settlers). Further, the whole problem of racial mixture can perhaps better be studied now than at any other period of our history. A generation ago, the half-castes and other mixed breeds were relatively few. A generation hence there will be hardly any fullbloods remaining. At present there are about 1,000 fullbloods* and 6,000 half castes; so that there is plenty of anthropological material. Further, the family relations of fullbloods and half castes can in most cases be ascertained by the careful investigator, which will certainly not be the case in another generation.

There is another aspect of the research which should be of interest to the sociologist. It involves the study of the effect of their changing environment upon these primitive peoples. In the following paper we give some notes on their method of life, habitats, mentality and economic capacity which should appeal to those who see in "racial mixture" one of the gravest problems confronting civilisation.

* Three-quarter castes are officially included with full-bloods in the census.

The widespread distribution of *Australoid* peoples, not only in Southern Asia but also in Europe in Paleolithic times, has been discussed by one of the authors in a number of publications*. The recent discovery of a dozen skeletons in Moravia, of prehistoric age and of a type practically indistinguishable from modern Australian aborigines†, is of special interest in connection with the study of the numerous racial stocks which have been mixed to form the Western European peoples. This aspect alone should stimulate research in our primitive Australian aborigines.

Our research was made possible by the courtesy and help of the members of the Aborigines Protection Board (and of its secretary, Mr. Pettitt‡), who authorised us to visit all their reserves in the Kamilaroi country. Further, we had the privilege of accompanying Mr. R. Donaldson, J.P. (the Board's Inspector), upon his inspection of these reserves. A grant from the University Research Fund defrayed some of our expenses, and has enabled us to reproduce more photographs than would have otherwise been possible. We are also much indebted to Mr. Harris of Walhallow, and Mr. Robertson, of Angledool, for their hospitality.

(b) Distribution of Aborigines.

John Fraser in his study of the Aborigines of New South Wales (Sydney, 1892), enumerates eight tribes in this State. His map shows that the Kamilaroi (whom he calls Kamalarai, extend from Singleton to Walgett, and from Coonabarabran to Bingara. They thus occupy the valley of the Namoi and of the Upper Hunter. (See fig. 1.) We may note incidentally here that the low divide at Cassilis

*"Evolution of Race and Culture". (G.T.) Geog. Review, 1921, New York.

† Personal communication from Professor Elliot Smith, F.R.S.

‡ Mr. Pettitt kindly revised section (d) Control of the Aborigines.

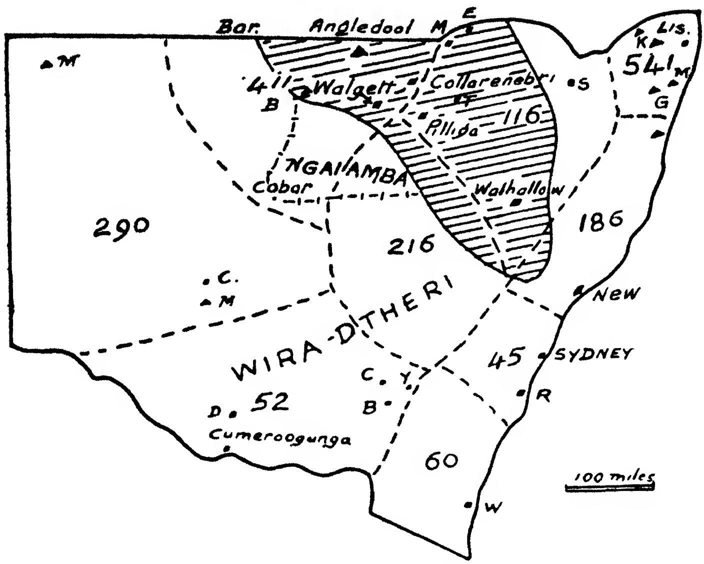


Fig. 1.—The distribution of the full-blood Aborigines in New South Wales in 1912. The Kamilaroi (and Eu-alaroi) region is ruled. Localities where more than 40 full-bloods live shown by triangles. Chief reserves by initials.

has very sensibly been ignored by this tribe, although most cartographers wrongly place a mountain range (the so-called Great Dividing Range) as a barrier across the Kamilaroi country, just south-west of Walhallow!

Beyond the Barwon, as far west as Barringun, extends the territory of the Eu-alaroi (or Walarai); and to the north-west, as far as Cobar and Bourke, is the Ngai-ambah tribe. These two tribes are, however, closely connected with the Kamilaroi. They have similar marriage-groups, and the languages are closely akin also. Thus the Kamilaroi people occupy the central-north of the state, consisting chiefly of the western slopes and middle west plains with an annual rainfall of 30 inches in the east and 15 inches in the west. Almost all of this country consists of open eucalypt forest.

A glance at the sketch map (fig. 1) shows that the fullblood aborigines of to-day are very unequally distributed through the State. They are most numerous in the extreme northeast in the valleys of the Richmond and Clarence Rivers. They are least numerous in the Murray Valley. Of the ten largest settlements of fullbloods (*i.e.*, where there are 40 or more), six in 1912 were found in this northeast corner of the State. The others were Brewarrina and Angledool in the north-central (Kamilaroi) region, and Milparinka and Mossgiel in the far western region. It is quite probable that the distribution was proportionately much the same in the days before white settlement. It may be noted here that further data concerning the Richmond River and Cumeroogunja (Murray) blacks have recently been collected by the Department of Geography of the University of Sydney.

Our traverse passed right across the Kamilaroi Region. We devoted some time to the aborigines at Walhallow, Pilliga, Angledool, Walgett and Collarenebri. At the three former places there are large government reserves with managers and teachers. At the two latter places the aborigines were only under police supervision.

(c) Aboriginal Census and Extinction.

The census is collected each year and affords sad proof of the rapid diminution of the numbers of fullbloods. There is an accompanying rise in the numbers of half-castes, so that there can be no doubt that the aboriginal population will in a short time be wholly merged into the white population (see fig. 2).

In 1882 a census of the aborigines was first taken, when the fullbloods numbered 6,540 and the half-castes 2,379. In 1897 the numbers in the two groups were equal, while in 1921 the proportions were 1,281 full-bloods and 6,270 half-castes; in other words the numbers had practically become

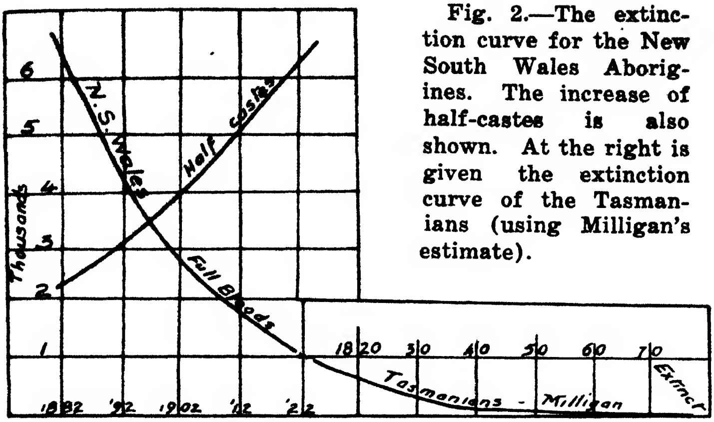


Fig. 2.—The extinction curve for the New South Wales Aborigines. The increase of half-castes is also shown. At the right is given the extinction curve of the Tasmanians (using Milligan's estimate).

reversed in a period of forty years. If we may assume that the curve of extinction can be prolonged smoothly, then it looks as if there will be no full-bloods left in forty years. In the figure we have added the extinction curve for the Tasmanian fullbloods, based on Milligan's rather doubtful estimates.

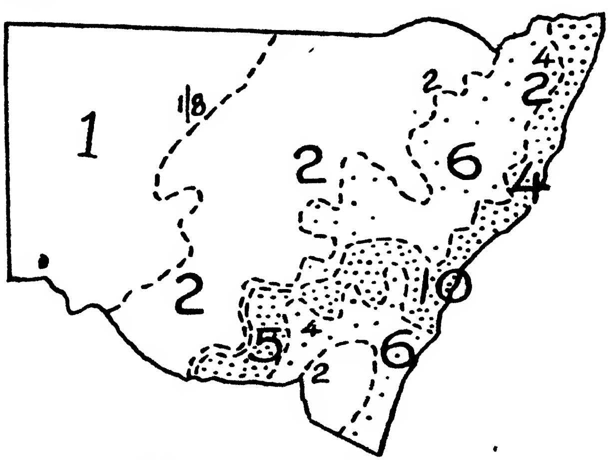


Fig 3.—Hybridism and White Population. Large figures show proportion of half-castes to one full-blood. Small figures show present density of white population. (Close dots over 4 per square mile of whites.)

The proportion of fullbloods to half-castes varies considerably in the various divisions of the state. Thus around Sydney there are ten half-castes to *one* fullblood. We have plotted these figures (see fig. 3), on a map showing also the distribution of white population. The proportion of racial mixture varies directly with the abundance of white population except in the north-east corner, where the aboriginal population is more nearly holding its own.

(d) Control of the Aborigines.

The Aborigines Protection Board consists of seven members, chiefly magistrates or members of Parliament, who administer the government vote of some £22,000 per annum. There is an inspector and one or two local boards who assist in supervising the larger reserves. The local Police are of the greatest value in this connection also.

The policy of the Board is to look after the aged aborigines and the mothers and children. These are being gradually segregated in one or other of the large reserves, where they can all be looked after, and where the children can be trained at school. There are about a score of these large aboriginal reserves in the state. The largest are located as follows:—(see initials on fig. 1).

Cumeroogunja and Moonacullah, near Deniliquin and the Murray River;

Wallaga Lake, Roseby Park, Cootamundra and Yass in the south;

Lismore, Kyogle, Cabbage Tree, Maclean and Grafton in the north-east corner;

Brewarrina, Walhallow, Pillaga, Boomi, Terryhiehie and Angledool in the Kamilaroi district.

The reserves usually comprise areas of 300 acres or less, though at Brewarrina (4,700), and Cumeroogunja (2,500),

they are much larger. There are about 100 reserves each less than 100 acres, and about 50 reserves of larger areas. These are situated at some considerable distance from townships, so as to minimise the drink trouble. On the more important, there is a manager and also a teacher. In these reserves the manager's wife usually trains the girls and women in the domestic arts.

The aborigines live in galvanised iron houses, each now costing about £100, and each containing a living room and a sleeping room. These houses are usually disposed in rows at one end of the reserve, while the manager's house and the school are placed at the other end. There are about 700 scholars in the state. The children are sent to school when they reach five or six years of age, and spend about five hours a day on tasks not unlike those of white children of the same age. Perhaps more attention is given to manual work such as raffia-plaiting and drawing for the younger children; gardening, sewing and farm work for the older children. The drawing, writing and singing impressed the writers very favourably.

As the boys grow older they accompany the men to the neighbouring towns or stations, and in most cases the young men soon learn to hold their own at jobs which do not make too great demands on their perseverance. Shearing, droving, horse-breaking, scrub-cutting, carting and similar work appeal to them most. The men usually return to their homes on the reserves at the week end, but are not encouraged to loaf about the houses during the week. This indeed is one of the chief difficulties with the idle members of the tribe. They are quite content to live on the rations issued to the women and children, passing their time in gambling and sleeping.

Many of the reserves have large areas of agricultural land, where the most industrious men are encouraged to

become self-supporting. There are also sheep and cattle belonging to many of the reserves. Thus Cumeroogunja (near Moama) in 1913 sowed 155 acres with wheat, and 60 acres was cut for hay, while they had 163 cattle and over 500 sheep. The produce for the year was worth £1,270. At Maclean (in the north-east), 30 acres of sugarcane yielded the aborigines £460 in 1911. Fruit trees have been planted in a number of reserves and are doing well. Of late, however, the outside demand for aboriginal labour has been so great that few remain to work the farms on the reserves. Hence many acres are leased to whites.

The welfare of the older girls is maintained by apprenticing them among the surrounding stations or in the metropolitan district as domestic helps or nursemaids. In the majority of cases they live there usefully and happily. A special training home is maintained at Cootamundra, and a female welfare officer inspects them periodically.

Rations and clothing are issued regularly to the aged, to invalids and to the women and children. To the adults the following are issued each week: 8 lbs. flour; 2 lbs. sugar; ¼ lb. tea; 7 lbs. meat, with a certain amount of tobacco and soap. Children get half the food supply. The men and boys get one suit and two shirts each per annum. The women and girls receive two dresses and five articles of underclothing each.

There are, of course, many families of aborigines who live far from any reserve. The advantage to the children and to the sick, which ensues from living on the reserves is, however, bringing them more and more under supervision.

(e). Mentality.

The three teachers at the aboriginal schools in the Kamilaroi district very kindly gave us lists of the scholars

with notes as to their intelligence (or "smartness"). We especially asked that this test should not deal with book-work or examinations. We have to thank Mrs. Wilkins and Messrs. Dallas and Constable for taking a considerable amount of trouble to compile these lists.

We endeavoured to obtain the opinion of the teachers as to the relative intelligences of the various breeds, but the result is not very satisfactory. One teacher gave it as his opinion that the blacks at the age of fourteen were about as intelligent as white children of the age of ten. He added that the boys lose their mental initiative about the age of 13 or 14, and go off rabbiting with dogs and traps, instead of attending school. Very soon they accompany the men to the shearing sheds or elsewhere, and thereafter do not have much to do with the reserves.

Table of 99 Children, 5 to 13 years.

Sex.	Full-blood and ¾.	Half-caste.	Quadroon and less.
Male.	8	22	17
Female.	10	25	17

The best way to express the mentality seems to be by frequency curves, where the various castes are allotted to four arbitrary "pigeon-holes." For these we have chosen as follows:

		Fullbloods.	%	Halfcastes.	%	Quadroons.	%
Grade A.	Very Intelligent . . .	3	17	12	25	10	30
B.	Intelligent .	9	50	18	38	10	30
C.	Rather Dull.	3	17	5	10	3	9
D.	Dull	3	17	12	26	11	31
	Totals . . .	18		47		34	

From the graph (fig. 4), it appears that the quadroons are the most numerous in the "very intelligent" grade, the half-castes rank next, and the fullbloods lowest. This

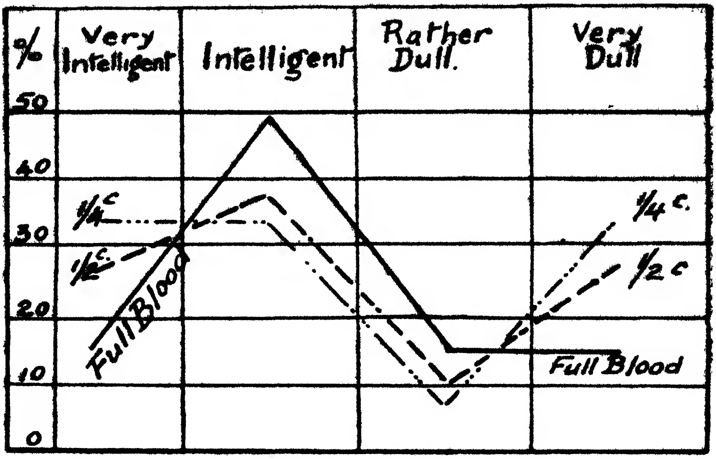


Fig. 4.—The intelligence of 99 Kamilaroi children (5-13 years) as classified into four arbitrary grades. Figures give percentages of total in the particular caste.

order curiously enough holds relatively for the dullest group also, where the quadroons are most numerous and the fullbloods proportionately few. Among children of average intelligence the order is reversed, the fullblood coming first and the quadroon last.

No doubt in the near future "Binet tests" will be devised which will give much more conclusive results.

(f) Marriage and Decay of the Clan System.

Many of the aborigines are now legally married, but they are as a whole rather lax in this respect. At one camp (far from any reserve), we were informed that of half a dozen couples, only one had been legally married. We were struck with the discrepancy in age in many marriages, and also by the large number of women who appeared to have been married twice. Probably in a number of cases irregular unions were later dignified by the term "marriage." This complication made the charting of family relationships very difficult. Furthermore, the Board

does not assume responsibility for quadroons and octoroons, so that there was a direct incentive for the lighter castes to make themselves out blacker than they were painted, so as to stay on the reserves.

The girls who are apprenticed in various households receive free clothing and free medical attention as well as a small salary. A proportion of the latter is retained by the Board until they set up homes of their own, when their savings often amount to a considerable sum. The girls return home at regular intervals and marriages between suitable individuals are encouraged. The welfare worker (as regards the girls), and the manager (as regards the men), report to the Board on such matters.

As a special privilege we were told the marriage classes of the Kamilaroi. These are, of course, well known to ethnologists. However, we repeat here the exogamous rules as we heard them at Angledool. The local pronunciation differs from that given by Howitt.

The full classes are:—

	Moiety A (Emu) Adult	Moiety B (Porcupine) Adult	Child	Child
Class X	Hibbai (f. Ivatha)	Gubbee (Gabbutha)	M.	K.
Class Y	Kombo (Bootha)	Murray (Madtha)	G.	H

For example:—A Hibbai man marries a Gabbutha woman (in the other moiety). The descent is through the mother, so the boys are Murray and the girls are Madtha (in the other class of the mother's moiety). Two of the common totems are Emu and Porcupine. Even to-day, as one of the women put it, "They don't like two 'emus' to marry, *too close* meat!"

These marriage rules are discussed in numerous publications; but one interesting aspect of the transition period

is the way in which these class-names are being adopted as surnames by the civilised aborigines. "Murray" is a common name among them, but (contrary to popular belief), it has no connection with the Scotch clan. (Of course many aborigines do take the name of a prominent white person in the district.) "Kombo" is also common as a surname. Gubbee (or Cubby), we met with once or twice. The name of the fourth class (Hibbai or Ipai), was not observed.

Chinese-Australian Hybrids.—On a recent journey to the Northern Territory, one of us (G.T.), was able to obtain photographs of an interesting mixed race at Camooweal, just on the Queensland border. Some of these are given on Plate XXVI. Several Chinese gardeners (from Canton we believe), had taken aboriginal wives. In the photographs both of these original races are shown. The husband of the black woman is not shown, but their progeny are the two younger women. The girl of 18 is the result of this cross, and to European eyes is more prepossessing than either of the parent races. This generation is marrying with Chinese (one of whom is illustrated), and producing Chinese quadroons. Three of these are illustrated.

The observer was not equipped to take measurements, but the following notes may be of interest. The half-castes as a whole resembled Chinese more than aboriginal. Of the quadroons three girls were rather more aboriginal in appearance than two boys. The larger eyes and fuller lips of the girls were perhaps derived from the aboriginal. The boys showed slightly oblique and smaller eyes and smaller noses. The children are said to be quite equal to the white children at the local school. The Chinese men, it was stated, manage the cooking and washing in addition

to their gardening—leaving the women with much more time for the children than is the case in most white families.

(g) Language.

It was disappointing to find that on many of the reserves there was no recollection of the aboriginal myths or customs. The children knew practically no aboriginal speech, though at Angledool they sang a song (alleged to be due to a Queensland Kanaka!) of whose meaning they had no idea. However, we found one old lady, a half-caste, see Plate XXIV. (top), who could help in this respect. A few of the characteristic riddles are repeated in a later paragraph.

The following vocabularies illustrate the differences in the various dialects surrounding the Kamilaroi peoples. It is perhaps unnecessary to caution readers that Kamilaroi itself varies from district to district, just as do the various dialects in Britain.

COMPARATIVE DIALECTS.*

English	Kamilaroi	Eualaroi	Ngai-amba	Wirah-dtheri	S. Queensland
Locality	Pilliga	Walgett	Brewarrina	Coonamble	St. George
one	Mahl ..	Beerah ...	Maggoo ...	Maggoo ...	Wangara
two	Bullar ...	Bullar ...	Bullahga ..	Bwalla ...	Bullari
three	Gullibar ...	Goolibah ...	...	Goolibar ...	Thirin
head	Gobgah ..	Dthaygal ...	Wah-lah ...	Bahlang ...	Bangoon
eye	Mil	Mil	Mil	Mil	Thilee
nose	Mor-roo ...	Mi-ootha ...	Moorrootha	Mooroo ...	Goo
hand	Murrah ...	...	...	...	Marah
good	Morrobah / Gabbah	Gabba ...	Gumbah ..	Gumbah ..	...
bad	Badthah / Gagi	Gahgi ...	Wurrai ...	Wurrai ..	Gadjah
water	Gahli ...	Gung-en ...	Gahlee	Gahlee ...	...
drink	Narroh-gi	...	Narrung-geri	...	...
blackfellow	Murri / Gu-wirringai	Dthain ...	May-ee ..	May-ee ...	Murree
woman ...	Eenah ...	Henna ...	Wiringah .	Wiringah ...	Mooghi
whitefellow ...	Wandah ...	Wandah ...	Wimmahn	Wandah	Widtha
kangaroo ...	Bowra ..	...	Marrowi ..	...	Bandah
boy	Kyangil ...	..	Warroo	Kyangil	..

Pronunciation.—'Ah'* is long as *'a'* in *bath*; *'ee'* as in *keep*; *'ai'* is the long *'i'* as in *vine*; *'ay'* as in *hay*; *'oo'* as in *food*; *'ow'* as in *cow*; *'u'*, *'y'* and *'i'* are short; *'g'* is hard; *'ng'* as in *singer*; *'dth'* as in *had they*. These are the forms generally used in the aboriginal locality-names, with which Australians are familiar.

The following is a Eualaroi corroboree song given by Old Helen at Angledool. She stamped round in a small circle, clapping two boomerangs at every syllable.

Nambaragah-goh gandah, garroh-gandah,
Gundarrah, gundarramah.
Gaggah gundarramah,
    Mah Mah.
Nungaribah gandah,
    Nambarogah.

This seems to be an invocation; the words meaning "*The Debbil-Debbil* (Gandah), *where does he live* (Nambarogah)," according to Helen.

She also told us a number of riddles, of which the following are representative.

1.

The Blackbird speaks:—
Koombai, Koombai, Goorahwingohlee.
(*Sweetheart, sweetheart, get food with me.*)

The Greenbird answers:—
Wahl, Wahl! Daindhu Babburr ngarrilee ngallinya.
(*No, No! People might see "us" tracks.*)

2

First animal says:—
Koombai, Koombai! Minyi-gindah, ngarral-dunnah dillay-dillay.
(*Comrade! How can you see from the side?*)

Second animal replies:—
Nindaganni Minyi ngarral-dunnah mooyoi-mooyoi.
(*And how can you see, looking from the nose?*)

Answer.—Crayfish (Ingah) and Crab (Nullahgah).

3

Why has the dove a blood-red eye?

Ngahn doo ngayee goh.
(Somebody rob him of eggs.)
Boo-om-ay nay narragang.
(Rob him; poor little thing.)
Mil goo-wambarrah.
(Eye red like blood.)

4

The song of the River-Mussel:—

Ballal-boh-ah, Gillanee-ah, Ngullungahnah.
(It is getting dry, all along the edge of the mud).
Yahn-dai-dai, Doorai-yah.
(Come along, all come close together.)

(h) Burial (Transition phase).

One of the most interesting localities in the State is the Aboriginal Cemetery, a few miles north of Collarenebri. It illustrates, in a notable way, the transition between the aboriginal culture and the white civilisation. The cemetery is enclosed in a neat netted fence, and contains an area of about 400 square yards. It is shaded by clumps of native flowering trees, such as "rosewood" (*Geijera parviflora*) (See Plate XX.).

The graves number thirty-three, and are not disposed regularly with regard to east and west. Each grave is usually marked out by four poles laid on the ground. It is, however, the covering which arouses attention. Every grave is ornamented by brightly-tinted crockery and glass-ware. Broken bottles and tumblers form the margin, while all the intervening space is filled with a jumble of broken glass and china, like a loose mosaic. Outside the enclosure are countless petrol tins, used to collect gaudy crockery for scores of miles.

Some of the ornaments are elaborate and unbroken, *e.g.*, a Dresden shepherdess, plates, lamp-bowls, and glasses, cruets, pepper-casters, dolls' heads, decanters, bovril, lysol and medicine bottles, egg-stands, beads, copper coins, and large shells were also common. On several graves small frames, like kite-frames, were ornamented with beads, and reminded us of some of the Central Australian "regalia" for corroborees. On a baby's grave lay a feeding-bottle. We were informed that the aborigines liked the police sergeant to read a service at the grave.

Several old aboriginal women have hitherto kept the cemetery in order. Occasionally they would laboriously remove all the crockery and "mosaic," wash it carefully, and replace it in the same position. Most of these old women have passed away, and with the death of the next it seems probable that this cemetery will share the fate of other land-marks of the aboriginal.

PART II.—ANTHROPOMETRY.

(i) Material.

Measurements have been made of 55 individuals of the Kamilaroi Tribe, New South Wales. In this paper are tabulated results for twenty-three adult males, thirteen adult females, and fourteen children, *viz.*, three male and eleven female. The measurements of five individuals, whose ancestry is doubtful or obscured by foreign crossing, are not discussed here.

Particular consideration has been given to the variations in measurements of individuals, resulting from racial crossing. Classified according to ancestry and sex, of those here tabulated, in the case of adults, eleven are full-blood males, eight are full-blood females, four are three-quarter caste males, three are three-quarter caste

females, six are half-caste males, and two are half-caste females. In the case of children, the measurements include those of one full-blood boy, two full-blood girls, two three-quarter caste boys, five three-quarter caste girls and two five-eighths caste girls.

Measurements and Observations: Explanatory Details.

Cranium and Face.—Measurements were made with the Flower's type of callipers, graduated in centimetres, and radiometer (Gray type), also graduated in centimetres. The land-marks selected are those set out in the hand-book, "Essentials of Anthropometry," by Louis R. Sullivan, issued by the American Museum of Natural History.

Indices. The anatomical face index = height of face (chin to nasion) divided by the width of the face.

The nasal index = width of the nose divided by the height of the nose.

Body.—Body measurements were made by means of an anthropometer graduated in inches. The height of the acromion and vertex, both sitting and standing, were measured, as well as the height of the distal point of the second finger when standing, and from these Trunk Length, Arm Length, and Leg Length were computed by the subtraction method.

Hair.—In all adults this was black (readily going grey with age). In some of the half-caste children it was dark brown. Among twenty full-bloods only three had hair approximating to curly. The remainder had hair with a wave. We saw only one full-blood (not measured) with definite curly hair. Straight hair or hair with a low wave was usual among the half-castes.

Ear.—In describing the lobe, the phrases used are those employed by Bertillon in his "Signaletic Instructions." "Descending attached" and "square" have *no lobe;*

"contour intermediate" has a *slight* lobe; "contour gulfed" has a *well-marked* lobe.

Eyes.—The scale of colours used for the eyes is that recommended in 1908 by the Anthropometric Committee of the British Association. The eyes have usually a muddy-brown iris, sometimes with a slate-blue border; the margin (sclerotic) is yellow white, usually bloodshot in the elders but clearer in the children.

Skin.—The skin-colour standard used is Broca's scale, published by Hrdlicka. This scale proved rather unsatisfactory; in many cases it was impossible to match at all closely actual skin colour with any colours of the standard. We owe to Mr. A. W. Gerard, A.I.A., popular names of the tints of the skin, which, in every case, were taken on the inner side of the upper arm. Broca's Scale (according to Hrdlicka) consists of eight plates of four colours each. Of these the first sixteen colours range from pale ochre to yellow-brown, and the last sixteen from a red ochre through red-brown to eight greys and blacks. The full-blood men are usually red-brown, only one being chocolate brown. The full-blood women are noticeably lighter, Indian red being the most common colour. The three-quarter castes are a little lighter, a sort of sepia with a touch of red, but the children are lighter (coming in Broca's *first* sixteen colours), i.e., yellow-brown. The half-castes are ochre, with a proportion of yellow-brown and Indian red.

There is here no justification for the term *Black-fellow;* (indeed none of their skin-tints appeared among Broca's grey-black colours). The face, however, is much darker than the under-arm, often a real chocolate colour. The soles of the feet are practically white.

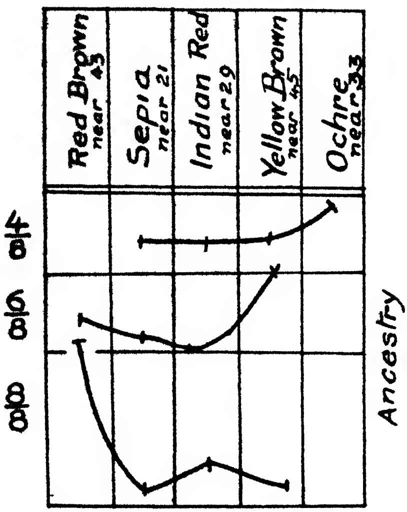


Fig. 5.—Colour of the skin (Broca's Scale) (under arm). Percentage curves with respect to different castes.

Tabulations and Frequency Curves.

In Tables 1, 2A, 2B, 2C, all measurements, as well as certain derived indices, are tabulated. In these tables, the classification is according to sex and maturity. Mean values of measurements are shown, but no particular significance is attached to these, since no account has here been taken of ancestry.

In Tables 3A and 3B the mean values of measurements classified according to ancestry, sex, and age are summarised. The number of measurements available in each case is shown.

Frequency curves have been drawn as far as possible from the insufficient available data. These are of value in that they indicate in some cases regular variations in the measurements, when considered from the point of view of ancestry. Where available, the data regarding children is indicated by broken-line curves.

(j) Discussion of Measurements.

Cephalic Index.—A progressive increase of cephalic index, with increase in proportion of white blood, is not apparent. From Table 3A, it will be seen that the mean cephalic indices for adults are as follows:—Full-bloods—males 73.6, females 74.4; three-quarter castes—males 70.6, females 76.6; for half-castes the values are—males 73.0, females 73.5. Some indication of a broadening of the head with white blood is, however, shown by the children.

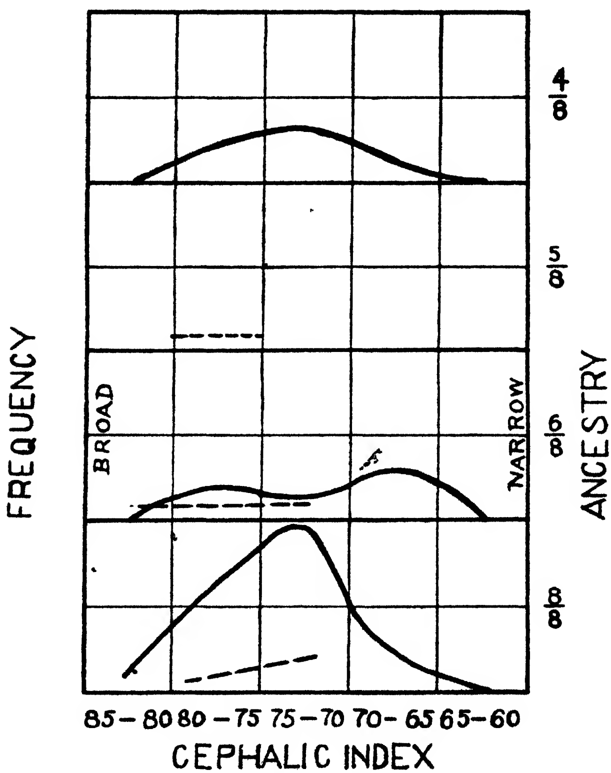


Fig. 6.—Frequency curves for the Cephalic index. No indication of broadening with increase of white blood is shown in the adults. A slight broadening is observed in the results for the 12 children (broken lines).

The frequency curves indicate a maximum for values of 70-75 in the case of full-bloods and half-castes. A similar value is probably indicated in the case of three-quarter castes, but a sufficient number of measurements was not available for the production of a smooth curve.

There is a marked uniformity in the measurements of head length and breadth. Only in the case of the male three-quarter castes, and there only in regard to head length, is the average deviation in excess of 0.5.

The measurements of the males vary to a greater degree than those of the females. In the case of the half-castes, the converse apparently holds, but the figures in the case of the females are based on measurements of two individuals only.

Anatomical Face Index.

The mean values of anatomical face indices, as set out in Tables 3A and 3B are, in the case of adults, full-bloods—male 90, and female 86; three-quarter castes—males 90, females 87; half-castes—males 88, females 83.

The indication is a slight change from the dolichopse towards the euryopse form, with increase in proportion of the white blood. This change is even more pronounced in the few measurements available in the case of children.

This tendency is apparent in the frequency curves. In the case of the full-bloods a maximum frequency is indicated for values of 85-90. In the case of the three-quarter castes the maximum frequency occurs for values of 90-95, and in the case of the half-castes the maximum occurs for values of 80-85. An arbitrary system of grouping has been adopted in plotting the frequency curves, which shows an apparent increase in value of anatomical face index in the case of the three-quarter castes, whereas,

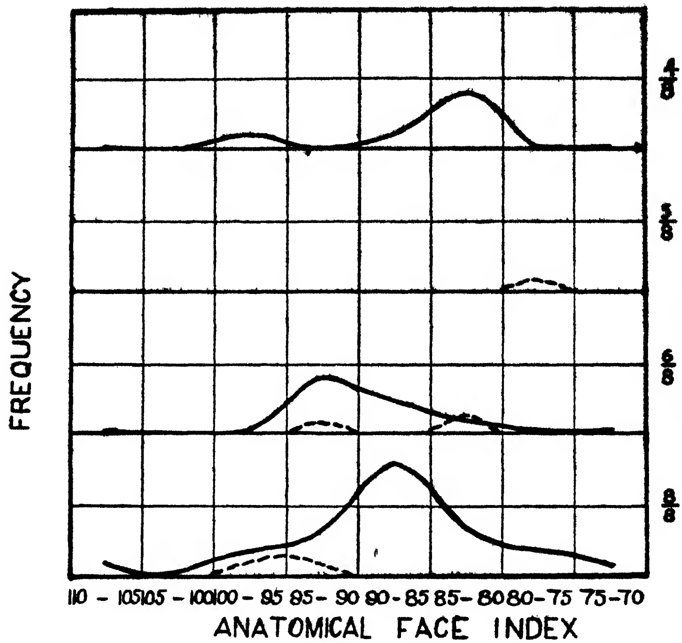


Fig. 7.—Anatomical face index. (Height of face divided by breadth). The frequency curves show that as the proportion of white blood increases the face becomes broader. (Broken lines are for children.)

actually the maximum occurs within the same limits as that for the full-bloods.

*Transverse Cephalo-facial Index.**

In the adult no regular progression is apparent or indicated with regard to this index. In the children the index drops from about 88 (full-blood), through 83 (three-quarter), to 78 (five-eighth).

Nasal Index.

The nasal index has yielded the most satisfactory and definite results in this investigation. The mean values

* This index is the width of the face divided by the width of the head.

of nasal indices taken from Table 3A are:—Full-bloods—males 108, females 108; three-quarter castes—males 103, females 104; half-castes—males 88, females 88. Here a very definite tendency towards a change from the platyrrhine towards the mesorrhine form, as the proportion of white blood increases, is indicated.

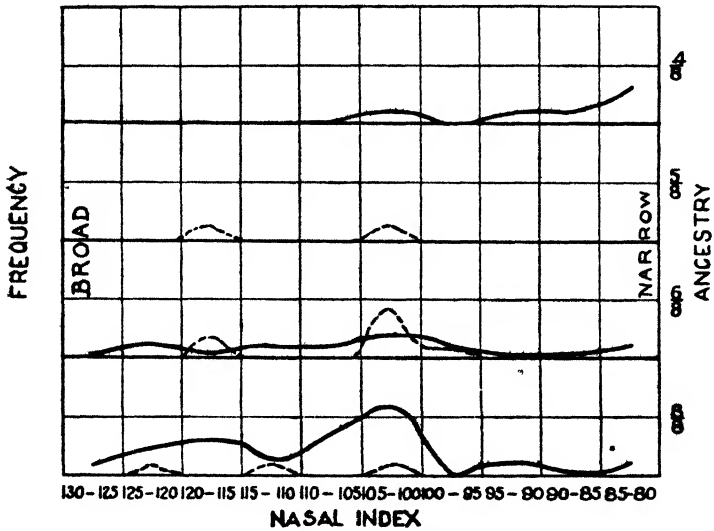


Fig. 8.—Nasal index frequency curves arranged according to ancestry. The nose becomes narrower as the proportion of white blood increases. Broken lines are for children.

The frequency curves are not so satisfactory, being bimodal and trimodal, due to paucity of measurements, but the decrease of value of the nasal index, between full-bloods and half-castes, is indicated.

The importance of considering the mean of a large number of measurements is here demonstrated. It was found that the average deviation and the coefficient of variation for the nasal measurements, generally speaking,

have a greater range in value than those for any other measurements tabulated.*

Just as Risley, in "The People of India," has laid down a law that "The social status of the members of a particular group varies in inverse ratio to the mean relative widths of their noses," so a similar generalisation might be made in regard to the aboriginal castes, substituting "the proportion of white blood" for "the social status" in the above.

The variation in children with regard to white blood is naturally not marked. The immature nose of white children is of much the same form as that of the full-blood child.

Total Height and Other Body Measurements.

These measurements are, generally speaking, uncertain and unsatisfactory. There is no indication of increase in stature, nor decrease in relative lengths of the limbs as compared with the trunk, with increase in proportion of white blood. The differences in the measurements tabulated, between full-bloods, three-quarter castes and half-castes are not greater than the differences which occur within a particular group.

Description of Plates.

PLATE XX.

(Top)—Front face and side face of young full-blood woman from St. George (Queensland), just over the border. Her measurements are given as No. 34 in tables.

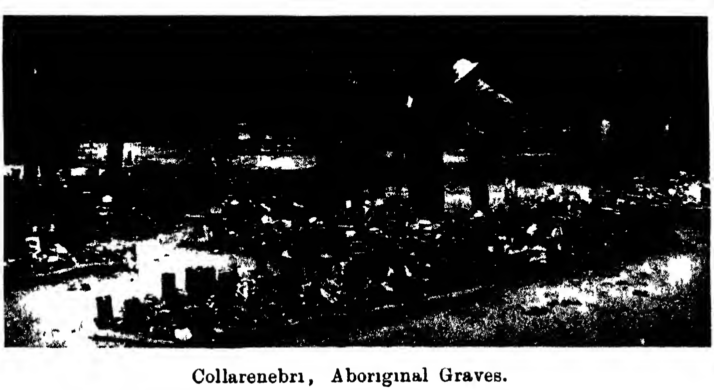
(Middle)—Profile photographs of young 6/8 black, his 8/8 father and an old full-blood (Nos. 8, 6, 7 in tables). All at Angledool.

---

* Tables giving Range of Variation and the Mean for each measurement, with average Deviation and Coefficient of Variation were prepared, but have not been printed owing to limits of space.

Walhallow; 8/8, 19 years, (No 34)

Angledool; 6/8, 8/8, 8/8, (Nos 8, 6, 7)



Collarenebri, Aboriginal Graves.

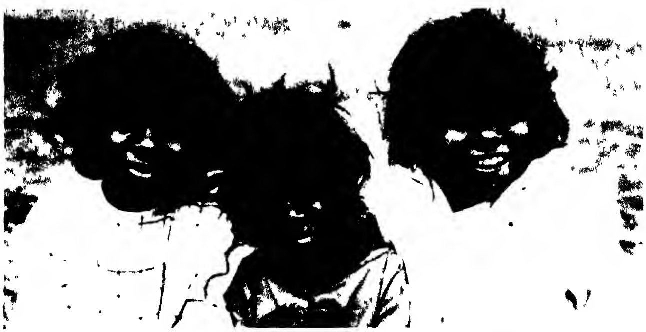
Collarenebri ; 8/8, 4/8, 6/8, 8/8, (Nos. 4, 3, 1, 2).

As above.

Collarenebri ; 8/8 (Wife of No. 4).

Walhallow ; 6/8

(No. 30), 6/8



Angledool ; 5/8 6/8 5/8

Angledool ; 6/8 (No. 35).

6/8 (No. 25).

(Bottom)—View of the Aboriginal Cemetery at Collarenebri, entirely maintained by the local blacks.

PLATE XXI.

All Collarenebri Aboriginals.

(Top and Middle)—Three grades are illustrated. The change from full blood to three-quarter blood to half-caste is well illustrated in the three right-hand figures (Nos. 4, 3, 1, 2 in Tables).

(Bottom)—Full-blood wife of No. 4.

PLATE XXII

(Top)—Woman, three-quarter blood, strong beard for a woman. Father full-blood, mother half-caste (Walhallow).

(Middle)—Three girls (from 6 to 8 years old) at Angledool. The two outer girls are sisters 5/8; the central girl is 6/8 black.

(Bottom)—Two 6/8 black sisters from Angledool (Nos. 35 and 25 in Tables).

PLATE XXIII.

(Top)—A Pilliga family, showing result of marriage of full-blood man and half-caste woman (Nos. 17 and 32 in Tables).

(Middle)—Three elderly half-castes at Walhallow. (The man is No. 22 in Table). His wife on left; her sister on right.

(Bottom)—The man is 4/8 African, 1/8 Australian, 3/8 white. He married a full-blood Australian. The children are 2/8 African, 9/16 Australian, and 3/16 white.

PLATE XXIV.

(Top)—Photos of Old Helen of Angledool, to whom we owe the riddles. Her father was white, her mother full-blood. (She has gray eyes.)

(Middle)—A half-caste family (first and second generation), from Pilliga.

(Bottom)—A family from Angledool. The mother (No. 36 in Tables) is a fine type of half-caste. Her husband is 3/8 black. The children are 7/16 black and quite intelligent.

PLATE XXV.

(Top and Middle)—A group at Pilliga. The boy is 6/8 black, the older woman is 3/8 black (but is practically indistinguishable from white), and the daughter (about 25 years) is 11/16 black. Note the elongated head of the boy, who is measured as No. 53 in the Tables.

(Bottom)—Full-blood woman (31 in Tables) and her baby of five months (from Pilliga).

PLATE XXVI.

Photographs illustrating a mixture of Chinese and Aboriginal blood at Camooweal (N.W. Queensland).

(Top Left)—Full-blood Queensland aboriginal about 50 years old (mother of the two young women), married to the Chinese partner of the man shown.

(Top Right)—Young woman (about 20 years), half Australian, half Chinese (married to man below).

(Bottom)—Chinese gardener (from Canton?), about 45 years. Woman is half black, half Chinese. Her children are quarter black and three-quarter Chinese.

Pilliga; Woman 4/8, Man 8/8, Children 6/8 (Nos. 32, 17).

Walhallow; All 4/8 (No. 22).

Pilliga; Man 4/8 African, 1/8 Black, 3/8 White (No. 20), Children 2/8 African, 9/16 Black, 3/16 White, (Nos. 40, 41).

Angledool; 4/8

4/8

Pilliga; All 4/8

Angledool; Mother 4/8, Children 7/16 (No 36).

Pilliga; 3/8 3½/8 7/8 (No 53) 5½/8

3/8

7/8 (No 53) 5½/8

Pilliga; 8/8, 5 months

Pilliga; 8/8 (No. 31)

8/8 Black

4 8 Black, 4/8 Chinese

Camooweal

Children 2/8 Bl. 6/8 Ch.; Woman 4 8 Bl. 4/8 Ch.; Man 8/8 Chinese

Camooweal.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

— —

MAY 7TH, 1924.

The Annual Meeting, being the four hundred and forty-fourth General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. R. H. Cambage, President in the Chair.

Forty-eight members and two visitors were present.

The certificates of sixteen candidates for admission as ordinary members were read: one for the second, and fifteen for the first time.

The following gentleman was duly elected an ordinary member of the Society:—James Peel Shelton.

It was announced that the following members had died during the recess:—Mr. Henry Deane and Mr. J. E. Miller.

A letter was read from Mrs. H. Deane expressing thanks for the Society's sympathy in her recent bereavement.

A letter was read from Mr. J. H. Maiden thanking the Society for greetings sent from members at the annual dinner.

A letter was read from the Royal Society, London, intimating that "Fellows of the Royal Societies in the Dominions be admitted to the meetings of the Society during the present year without an introduction from a Fellow."

The Annual Financial Statement for the year ended 31st March, 1924, was submitted to members, and on the motion of Professor Vonwiller, seconded by Dr. Wardlaw, was unanimously adopted:—

GENERAL ACCOUNT.

RECEIPTS.

		£ s. d.	£ s. d
To Revenue—			
Subscriptions		666 15 0	
Rents—			
Offices	£616 4 0		
Hall and Library	223 1 2		
		839 5 2	
Sundry Receipts		11 11 1	
Government Subsidy for 1923		400 0 0	
			1917 11 3
„ Clarke Memorial Fund—			
Loan to General Fund (Interest)			56 11 8
„ Donations to Cost of Alterations			10 10 0
„ Building Loan Fund			30 0 0
„ Balance—			
Union Bank of Australia Ltd.			
Overdrawn Account, Head Office		3469 2 0	
Less:—Petty Cash on hand		5 2 2	
			3463 19 10
			£5478 12 9

PAYMENTS.

		£ s. d.	£ s. d.
By Balance as at 31st March, 1923			3819 11 2
„ Administrative Expenditure—			
„ Salaries and Wages—			
Office Salary & Accountancy Fees	£253 15 0		
Assistant Librarian	48 0 0		
Caretaker	242 0 9		
		543 15 9	
„ Printing, Stationery, Advertising and Stamps—			
Stamps and Telegrams	40 6 2		
Office Sundries, Stationery, etc.	7 15 8		
Advertising	12 0 3		
Printing	40 16 3		
		100 18 4	
Carried forward		644 14 1	3819 11 2

PAYMENTS—*continued.*	£ s. d.	£ s. d.	£ s. d.
Brought forward		644 14 1	3819 11 2
By Rates, Taxes and Services—			
Electric Light	72 1 5		
Gas	10 17 10		
Insurance	32 16 11		
Rates	178 8 3		
Telephone	15 7 5	309 11 10	
„ Printing and Publishing Society's Volume—			
Printing, etc.	124 6 6		
Bookbinding	41 0 0	165 6 6	
„ Library—			
Books and Periodicals	57 18 8		
Bookbinding	31 19 0	89 17 8	
„ Sundry Expenses—			
Repairs	10 7 1		
Lantern Operator	23 16 0		
Bank Charges	0 8 10		
Sundries	62 17 8		
Legal Expenses	0 10 6	98 0 1	
„ Interest—			
Union Bank of Australia Ltd.	236 19 0		
Clarke Memorial Fund ..	56 11 8	293 10 8	
			1601 0 10
„ Building Loan Fund—			
Repayment of Loan		50 0 0	
Payment of Interest		8 0 9	
			58 0 9
			£5478 12 9

CLARKE MEMORIAL FUND.

BALANCE SHEET AS AT 31st MARCH, 1924.

LIABILITIES.	£ s. d.
Accumulation Fund—	
Balance as at 31st March, 1923	849 0 2
Additions during the year—	
Interest—General Fund	56 11 8
	£905 11 10

ASSETS.

	£	s.	d.
Loan to General Fund	905	11	10
	£905	11	10

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31st MARCH, 1924.

RECEIPTS.

	£	s.	d.
To Interest—Loan to General Fund	56	11	8
	£56	11	8

PAYMENTS.

	£	s.	d.
By Loan to General Fund	56	11	8
	£56	11	8

Compiled from the Books and Accounts of the Royal Society of New South Wales and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D.,
Honorary Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.P.A.,
Auditor.

SYDNEY, 8TH APRIL, 1924.

On the motion of Mr. W. Welch, seconded by Mr. A. E. Stephen, Mr. W. P. Minell was duly elected Auditor for the current year.

It was announced that the Council had awarded the Clarke Memorial Medal to Mr. J. H. Maiden, I.S.O., F.R.S., F.L.S.

The President announced that the following Popular Science Lectures would be delivered during the Session:—

June 19—"Conditions of Life and of Travel in the Interior of Australia," by W. G. Woolnough, D.Sc., F.G.S.

July 17—"Experimental Observations on the Organisation of the Human Nervous System," by Professor J. I. Hunter, M.D., Ch.M.

August 21—"Solar Radiation," by J. J. Richardson, A.M.I.E.E.

September 18—"Science and the Land Industries," by Professor R. D. Watt, M.A., B.Sc.

The Annual Report of the Council was read, and on the motion of Professor O. U. Vonwiller, was adopted:—

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1923-1924. (1st May to 30th April).

The Council regret to report the loss by death of His Excellency Sir Walter Davidson, Vice-Patron of the Society, and of seven ordinary members. Sixteen members have resigned and two names were removed from the list of members through non-payment of subscriptions. On the other hand, twenty-seven ordinary members and one honorary member have been elected during the year. To-day (30th April, 1924) the roll of members stands at 375.

During the Society's year there have been eight monthly meetings and ten Council meetings.

Four Popular Science Lectures were given, namely:—

June 21—"Some Wonders of the Australian Flora," by R. T. Baker.

July 19—"Historical and Modern Practice of Quarantine," by J. H. L. Cumpston, M.D., D.P.H.

August 16—"Some Industrial Achievements of Organic Chemistry," by Acting-Professor G. Harker, D.Sc.

September 20—"Some Ancient Volcanoes of Australia," by W. R. Browne, D.Sc.

Meetings were held throughout the Session by the Sections of Geology, Agriculture and Industry.

Twenty-seven papers were read at the Monthly Meetings, and these, with a good number of exhibits, afforded much instruction and interest to members of the Society.

The Annual Dinner for 1922-23, also that for 1923-24, took place at the Union Refectory, Sydney University, on 26th April, 1923, and 29th April, 1924, respectively, when we were honoured on the first occasion by the company of the Honourable C. W. Oakes, C.M.G., M.L.A., Acting-Premier of New South Wales, and on the second occasion by the Honourable Sir William Cullen, K.C.M.G., M.A., LL.D., Lieutenant Governor and Chief Justice of New South Wales, and Chancellor of the University of Sydney, also in both instances by the Presidents of several societies.

During last September, those delegates to the Pan-Pacific Science Congress arriving from the East were welcomed by the President in the Society's Hall and the rooms of the Society were made available to them during their stay in Sydney.

Some alterations have been made for printing the future volumes of the Society's Journal and Proceedings, which will now be set on the linotype machine. In consequence the Council has decided that in future all papers offered to the Society must be remitted to the Honorary Secretaries not less than fourteen days before the date of the General Monthly Meeting at which the paper is proposed to be read. Authors are also advised to omit tabular matter as far as possible, especially small tables consisting of only two or three lines.

The donations to the library have been as follows:—16 volumes, 798 parts, 23 reports, 6 maps, 1 calendar and 1 catalogue.

* * * * *

The following donations were laid upon the table:—17 volumes, 502 parts, 7 reports, 19 maps and 1 calendar.

The President, Mr. R. H. Cambage, then delivered his address, which was broadcasted by Farmer and Company.

There being no other nominations, the President declared the following gentlemen to be officers and council for the coming year:—

President:
C. ANDERSON, M.A., D.Sc.

Vice-Presidents:

Prof. C. E. FAWSITT, D.Sc., Ph.D.	E. C. ANDREWS, B.A., F.G.S.
J. NANGLE, O.B.E., F.R.A.S.	R. H. CAMBAGE, F.L.S.

Hon. Treasurer:
Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

Prof. O. U. VONWILLER, B.Sc.	G. A. WATERHOUSE, D.Sc., B.E., F.E.S.

Members of Council:

Assist.-Prof. L. A. COTTON, M.A., D.Sc.	W. POOLE, M.E., M. Inst. C.E., M.I.M.M. M.I.E., Asst. M. Am. M.I.E.
Prof. Sir EDGEWORTH DAVID, K.B.E., C.M.G., D.S.O., F.R.S., D.Sc.	H. G. SMITH, F.C.S.
W. S. DUN.	Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.
R. GREIG-SMITH, D.Sc., M.Sc.	Prof. R. D. WATT, M.A., B.Sc.
T. H. HOUGHTON, M.Inst.C.E., M.I.Mech E.	W. G. WOOLNOUGH, D.Sc., F.G.S.

The out-going President then installed Dr. C. Anderson as President for the ensuing year, and the latter briefly returned thanks.

On the motion of Sir Edgeworth David, a hearty vote of thanks was accorded to the retiring President for his valuable address.

Mr. R. H. Cambage briefly acknowledged the compliment.

JUNE 4TH, 1924.

The four hundred and forty-fifth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President in the Chair.

Thirty-eight members and four visitors were present.

The President extended a hearty welcome to Dr. V. Stefansson, the arctic explorer, Mr. H. Sefton-Jones, of

London, and Mr. W. B. Alexander, Director of the Commonwealth Prickly Pear Laboratory, Brisbane.

The President announced that several members of the Society had received distinctions since last meeting, and offered the congratulations of the Society to Sir John Sulman, who had been created a Knight Bachelor, G. A. Waterhouse on his attaining the Degree of Doctor of Science, Professor J. I. Hunter the Degree of Doctor of Medicine, and J. J. C. Bradfield the Degree of Doctor of Science in Engineering.

The certificates of seventeen candidates for admission as ordinary members were read: fifteen for the second, and two for the first time.

The following gentlemen were duly elected ordinary members of the Society:—Victor Albert Bailey, Reginald E. Dickinson, George Zephirin Dupain, Frederick Alldis Eastaugh, Ernest Rudolph Holme, Leo Joseph Jones, Edward Joseph Kenny, Thomas David James Leech, Arthur James Mann, Malcolm Morrison, Arthur Launcelot Mullens, Arnold Philip Mullens, Robert Thompson Wade, Leslie Vickery Waterhouse and William John Williams.

The following donations were laid upon the table:—1 volume, 99 parts, 1 map and 2 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Differential Elevation near Sydney," by C. Hedley, F.L.S., which in his absence was read by Mr. T. Hodge Smith.

2. "A Contribution to the Geology of the Irwin River Valley of Western Australia," by W. G. Woolnough, D.Sc., F.G.S., and J. L. Somerville, B.Sc.

Mr. H. Sefton-Jones gave an account of his recent trip to Trinil (Java), the site of the discovery of the fossil remains of *Pithecanthropus erectus*. He exhibited a

number of fossil bones, from near the spot where Dr. Dubois, some twenty years ago, had found the skull of the Java apeman.

At the invitation of the President, Dr. Stefansson gave an account of some of his experiences within the Arctic Circle. His remarks were very much appreciated by all the members present.

JULY 2ND, 1924.

The four hundred and forty-sixth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President, in the Chair.

Seventy-seven members and visitors were present.

The certificates of three candidates for admission as ordinary members were read: two for the second and one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—Harvey Nickoll and Herbert William Thompson.

The following donations were laid upon the table:—10 volumes, 175 parts, 2 reports and 1 map.

To commemorate the Centenary of Lord Kelvin, born 26th June, 1824, Professor H. S. Carslaw, M.A., Sc.D., gave an address entitled:—"The life and work of Lord Kelvin."

On the motion of Professor Vonwiller a vote of thanks was accorded to Professor Carslaw for his very interesting address.

THE FOLLOWING PAPERS WERE READ BY TITLE ONLY:

1. "The Essential Oil of *Backhousia sciadophora* (N.O. Myrtaceæ) F.v.M.," by A. R. Penfold, F.A.C.I., F.C.S.

2. "The Germicidal Values of the Pure Constituents of Australian Essential Oils," together with those for some Essential Oil Isolates and Synthetics, by A. R. Penfold, F.A.C.I., F.C.S., and R. Grant, F.C.S.

3. "Notes on *Eucalyptus piperita* and its Essential Oils," with special reference to their Piperitone Content, Part I, by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.T.C., A.A.C.I.

AUGUST 6TH, 1924.

The four hundred and forty-seventh General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President, in the Chair.

Thirty-two members were present.

The certificate of one candidate for admission as an ordinary member was read for the second time.

The following gentleman was duly elected an ordinary member of the Society:—James R. M. Robertson.

A letter was read from Professor Liversidge, thanking the Society for greetings sent from members at the Annual Dinner.

The following donations were laid upon the table:—3 volumes, 121 parts, 3 reports and 1 map.

THE FOLLOWING PAPER WAS READ:

1. "Notes on the Physiography and Geology of the Upper Hunter River," by Assistant-Professor W. R. Browne, D.Sc. Remarks were made by Dr. W. G. Woolnough, Professor L. A. Cotton, Messrs. A. E. Stephen and G. D. Osborne.

The following papers which were postponed from last meeting were read and discussed.

1. "The Essential Oil of *Backhousia sciadophora* (N.O. Myrtaceæ) F.v.M.," by A. R. Penfold, F.A.C.I., F.C.S.
2. "The Germicidal Values of the Pure Constituents of Australian Essential Oils," together with those for some Essential Oil Isolates and Synthetics, by A. R. Penfold, F.A.C.I., F.C.S., and R. Grant, F.C.S. Remarks were made by Professor O. U. Vonwiller and Mr. R. W. Challinor.
3. "Notes on *Eucalyptus piperita* and its Essential Oils," with special reference to their Piperitone Content, Part I, by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.T.C., A.A.C.I.

Professor L. Harrison delivered an interesting address on the proposed Biological Survey of the National Park.

SEPTEMBER 3RD, 1924.

The four hundred and forty-eighth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President in the Chair.

Nineteen members and two visitors were present.

The President announced the death of the Rev. A. G. Stoddart, who was elected a member in 1903.

The certificate of one candidate for admission as an ordinary member was read for the first time.

The following donations were laid upon the table:—5 volumes, 58 parts and 1 report.

The President made the following announcement:—"The Council wishes to draw the attention of members of the Society to the facilities that are at present available for the deposit of money at call with the Society. Owing to the recent extensions to the Society's premises, the overdraft with the bank has been considerably increased,

and to assist in keeping this as low as possible the Hon. Treasurer has been empowered to receive sums of money in multiples of ten pounds to be repayable at call and bearing interest at the rate of five per cent. per annum calculated on the daily balance. These terms are more advantageous than those of the Savings Bank and in addition any sums lent will assist the Society. The deposits will be used to reduce the overdraft, so only a sum limited by the amount of overdraft can be received. Usually deposits can be withdrawn at twenty-four hours' notice."

THE FOLLOWING PAPERS WERE READ:

1. "Notes on Boronia in the Pinnate Section, with a description of a new species," by Edwin Cheel. Remarks were made by Messrs. A. R. Penfold and A. A. Hamilton.

2. "Evidence of a Negative Movement of the Strand Line of 400 feet in New South Wales," by T. Hodge Smith and Tom Iredale.

3. "The Change of Resistance of Molybdenite due to Light," by S. L. Martin, B.Sc. (communicated by Professor O. U. Vonwiller). Remarks were made by Professor Parnell, of Queensland University.

OCTOBER 1st, 1924.

The four hundred and forty-ninth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President in the Chair.

Thirty-seven members were present.

The President announced the deaths of Mr. H. G. Smith, a past president, Mr. T. H. Houghton, a past president, and the Hon. H. E. Kater.

The President also announced that the following resolution had been passed by the Council.

"That this Council of the Royal Society of New South Wales record in its minutes its high appreciation of the services of its late member, Henry George Smith, in the promotion of the interests of the Society, in the advancement of knowledge in the domain of chemistry, and in extending the avenues for the development of the resources of the State of New South Wales and of the Commonwealth of Australia."

Letters were read from Mrs. Stoddart and Mrs. Kater expressing thanks for the Society's sympathy in their recent bereavement.

The certificates of two candidates for admission as ordinary members were read: one for the second and one for the first time.

The following gentleman was duly elected an ordinary member of the Society:—David Horace Love.

The President announced that the Council had established a Section of Physical Science, and members were invited to attend a meeting to be held on the 16th October.

The President announced that a meeting would be held at the University of Sydney on Thursday, 23rd October, to commemorate the Centenary of the publication of Sadi Carnot's "*Réflexions sur la Puissance Motrice du Feu,*" and that the Royal Society had been invited to be represented at the meeting.

The following donations were laid upon the table:—6 volumes and 107 parts.

THE FOLLOWING PAPERS WERE READ:

1. "Note on the Structure of some Eucalyptus Woods," by M. B. Welch, B.Sc., A.I.C. Remarks were made by Messrs. R. T. Baker, A. A. Hamilton, W. Poole and A. B. Hector.

2. "A description of a new species of Eucalypt from Southern New South Wales," by W. A. W. de Beuzeville and M. B. Welch, B.Sc. Remarks were made by Mr. R. T. Baker .

3. "The Essential Oils of *Melaleuca erubescens* and *M. hypericifolia*," by A. R. Penfold, F.A.C.I., F.C.S. Remarks were made by Mr. M. B. Welch.

4. "On the Stratigraphy of the Basal Portions of the Permo-Carboniferous System in the Hunter River District," by Assistant-Professor W. R. Browne, D.Sc., and W. S. Dun.

5. "Notes on Melaleuca, with descriptions of two new species and a new variety," by Edwin Cheel.

NOVEMBER 5TH, 1924.

The four hundred and fiftieth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President in the Chair.

Thirty-eight members and one visitor were present.

The President announced the deaths of Messrs. T. F. Furber and W. P. Faithfull.

The President also announced that the following resolution had been passed by the Council:—

"That the members of this Council desire to place on record their very high appreciation of the services rendered to the Society by their late colleague, Mr. T. H. Houghton, M.Inst.C.E., a past-president, who was ever ready to place his professional knowledge and experience as a supervisor at the disposal of the Council in all matters relating to structural alterations and extensions to the Society's House, and has done this on many occasions to the Society's great advantage."

Letters were read from Mrs. H. G. Smith, Mrs. T. H. Houghton and Mrs. T. F. Furber, expressing thanks for the Society's sympathy in their recent bereavements.

The certificates of three candidates for admission as ordinary members were read: one for the second and two for the first time.

The following gentleman was duly elected an ordinary member of the Society:—Joseph Durham.

The President announced that the inaugural meeting of the Section of Physical Science was held at the Royal Society's House, on Thursday, 16th October, 1924, at 4.30 p.m., and the following officers elected:—

Chairman: Professor O. U. Vonwiller.

Hon. Secretaries: Professor V. A. Bailey, Mr. J. J. Richardson.

Committee: Rev. E. F. Pigot, Professor J. P. V. Madsen, Mr. A. B. B. Ranclaud, Mr. E. M. Wellish.

It was also announced that meetings would be held on the third Thursday in each month, at 4.30 p.m.

The following donations were laid upon the table:—3 volumes, 135 parts and 1 calendar.

THE FOLLOWING PAPER WAS READ:

1. "Landslides near Picton and notes on the local vegetation," by R. H. Cambage, F.L.S. Remarks were made by Professor L. A. Cotton and Dr. W. R. Browne.

Professor H. G. Chapman gave a short address on "Recent Advances in Industrial Hygiene" met with during his recent visit to Great Britain. Remarks were made by Dr. G. Harker, Mr. W. Poole and Dr. Greig-Smith.

EXHIBIT.:

Mr. E. Cheel exhibited specimens of various species of Melaleuca in illustration of his paper read at the October meeting.

DECEMBER 3RD, 1924.

The four hundred and fifty-first General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. C. Anderson, President in the Chair.

Thirty-four members and one visitor were present.

The President welcomed Mr. David Unaipon, a direct descendant of the race which inhabited Australia before the arrival of the white man, now in Sydney on mission work, who expressed his appreciation at having been invited to be present.

The President announced the death of Mr. W. E. Abbott, who was elected a member in 1877.

Letters were read from Mrs. Faithfull and Mr. Macartney Abbott expressing thanks for the Society's sympathy in their recent bereavements.

The certificates of three candidates for admission as ordinary members were read: two for the second and one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—James Kenner and Frederick Stapleton Mance.

The following donations were laid upon the table:—6 volumes, 84 parts and 2 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Acacia Seedlings," Part X, by R. H. Cambage, F.L.S. Remarks were made by Mr. E. C. Andrews.

2. "Kamilaroi and White," a study of Racial Mixture in New South Wales, by Professor Griffith Taylor, D.Sc., B.E., and F. Jardine, B.Sc.

3. "A further contribution to the knowledge of Silky Oaks," by M. B. Welch, B.Sc. Remarks were made by Mr. A. A. Hamilton.

4. "The Essential Oil of *Boronia safrolifera*," by A. R. Penfold, F.A.C.I., F.C.S. Remarks were made by Mr. A. A. Hamilton.

5. "A Chemical Examination of the Seeds of the 'Bunya Bunya'," Part I, by F. R. Morrison, A.S.T.C., A.A.C.I. Remarks were made by Mr. A. R. Penfold.

6. "Notes on the Petrology of the Prospect Intrusion," with special reference to the genesis of the so-called secondary minerals, by Assistant-Professor W. R. Browne, D.Sc.

GEOLOGICAL SECTION.

ABSTRACT OF THE PROCEEDINGS

OF THE

GEOLOGICAL SECTION.

Eight meetings of the Section were held during the year. The average attendance was eleven members and two visitors.

Annual Meeting, 16th May, 1924.

Mr. E. C. Andrews in the Chair.

Thirteen members were present.

Professor Sir Edgeworth David was elected Chairman for the year, and Mr. W. S. Dun, Honorary Secretary.

EXHIBITS:

By Mr. T. Hodge Smith on behalf of the Australian Museum, Boulders containing shells dredged on sandy bottom at a depth of 70–75 fathoms off Ulladulla, Long Reef, and various localities off the Coast. Specimens presented by the New State Fish Trawling Company.

By Mr. G. W. Card—from the Mining Museum—(*a*) Sandstone "Balls" from the Broken Hill Proprietary Silica Quarry, Wondabyne, Hawkesbury River. The specimens show colouration banding, by which means the true position of the ball can be determined readily. There is no lithological difference between ball and matrix, and it cannot be regarded as a concretion. The general symmetry of the "Ball" may be compared with the limestone specimen from Bowen exhibited previously; (*b*) Marine shells from Towamba, Kiah River—beyond tidal limits; (*c*) Series of photographs of Phosphate Deposits, Nauru; (*d*) Specimens of plastic asbestos and cone structure in Serpentine from South Africa.

Mr. L. J. Jones delivered a lecturette, illustrated by sections and photographs, on the general geology of the Central portion of Western Australia.

Monthly Meeting, 20th June, 1924.

Professor Sir Edgeworth David in the Chair.

Seventeen members and two visitors present.

EXHIBITS:

1. By Professor W. R. Browne—Marine fossils in ferruginous grit overlying the coal seam near Twin Trig. Station, Tallong.

The exhibit was discussed by the Chairman, Messrs. Jones, Willan, Morrison, Dr. Woolnough and Professor Cotton. The reliability of the Marangaroo conglomerate was touched on.

2. Mr. G. W. Card—from the Mining Museum—Obsidianites from Ooldea.

Mr. L. J. Jones showed lantern slides illustrating his lecturette on the Central portion of Western Australia.

A vote of thanks was carried.

Monthly Meeting, 18th July, 1924.

Professor Sir Edgeworth David in the Chair.

Fourteen members and five visitors present.

EXHIBITS:

1. By G. W. Card, from the Mining Museum—Green turquoise from Dayborough, Queensland, and blue felsite.

2. By Mr. T. Hodge Smith—Yttrio-cerite from Orange County, N.Y.

3. By Mr. T. Mitchell—Branchiostegal plates of a fish from the Lower Marine Series, Allandale.

4. By Mr. W. S. Dun—Specimens of new species of *Aviculopecten* and *Spirifer* from the Kimberley District, W.A., collected by Mr. T. Blatchford.

The discussion of Mr. Jones' paper was continued—Professor David described in detail the section from Derby to Melville Island.

Monthly Meeting, 15th August, 1924.

Professor Sir Edgeworth David in the Chair.

Seven members and one visitor present.

EXHIBITS:

Decomposed and fresh material from Mount Charlton, Queensland, in connection with Longley's Studies on Chlorine Content of Water.

Discussed by Professor Browne, Dr. Woolnough, the Chairman and Messrs. Poole and Willan.

The Discussion of the paper by Dr. W. G. Woolnough and Mr. Somerville on "A Contribution to the Geology of the Irwin River" lead to the following points—

1. The marked unconformities in the Precambrians to the South.

2. The zoning of the Irwin River area complicated by the paucity of outcrops. Therefore two glacial maxima, one at the base and another nearly halfway up in the Lower Marines, but glacial conditions prevailed into and above the Coal Measures. The coal is of the Collie type, woody structures being clearly visible.

3. There are three well marked lines of faulting—(*a*) fault to the east separating the Pre-Cambrian; (*b*) fault on the western side and (*c*) a fault forming the western margin of the Plateau area. Soundings suggest another fault along the Continental Border.

4. The Plateau Formation was formed as a hard crust under peneplain conditions, the surface hard layers are a function of the underlying rocks—much of the so-called Desert Sandstone belongs to this period and probably developed on a peneplain of Upper Miocene Age.

The paper was discussed by Professors Cotton, Browne, Mr. Poole and the Chairman.

Monthly Meeting, 19th September, 1924.

Professor Sir Edgeworth David in the Chair.

Eleven members and three visitors present.

EXHIBITS:

1. By Mr. G. W. Card, Mining Museum—Concretions from Wondabyne.

2. By Professor W. R. Browne—Twinned glendonites from Crookhaven Heads collected by Messrs. Lamb and Baker.

3. By Mr. G. D. Osborne—Specimens showing contemporaneous erosion, varve series, Seaham.

4. By Mr. T. L. Willan—Geological map of the Leadville District.

5. By Mr. W. S. Dun—Fossil Fish from Brookvale.

Messrs. T. Hodge Smith and T. Iredale presented a paper, "Evidence of a negative movement of the Strand Line of 400 feet in New South Wales." The paper is published in the Journal and was discussed by the Chairman, Professors Cotton and Browne and Messrs. Willan and Dun.

Monthly Meeting, 17th October, 1924.

Professor Sir Edgeworth David in the Chair.

Nine members present.

EXHIBITS:

1. By Professor Cotton—Tuffaceous limestone with *Lepidocychina,* from Matapan, Mandated Territory, New Guinea, collected by Mr. E. H. Briggs.

2. By Mr. G. W. Card, Mining Museum—Quartz breccia, Transvaal and paper on platinum bearing quartz.

3. By Mr. H. G. Raggatt—exhibited and gave notes on Tertiary sands from Dalton. The sands are overlaid by from 6″–16″ of clays and probably represent a lake deposit. The leaf bearing quartzites may be older than the sands and cover an area of from 10–15 acres.

4. By Professor W. R. Browne—Tillite from Murrurundi district. He pointed out that the "Cherty shales" of T. W. E. David and J. E. Carne are varve beds.

Remarks were made on a recent trip to Murrurundi. Attention was drawn to the occurrence of the basal conglomerates of the Narrabeen stage in that district and evidence given as to the Post-Triassic age of the Wingen Fault.—Discussed by Mr. C. A. Sussmilch.

Messrs. W. R. Browne and W. S. Dun presented a note on the stratigraphy of the basal portions of the Permo-Carboniferous system in the Hunter River District. The beds occurring above the Kuttung are regarded at the base of the Permo-Carboniferous.—Discussed by the Chairman, and Messrs. Sussmilch and Osborne.

Monthly Meeting, 11th November, 1924.

Professor Sir Edgeworth David in the Chair.

Nine members and three visitors present.

EXHIBITS:

1. By Mr. L. L. Waterhouse—internal casts of *Cleobis grandis* in coarse crystalline sandstone from Conjola (Miss I. A. Brown).

2. By Mr. G. W. Card, Mining Museum—Metallic Tantalum, wire and sheet, Mount Isa Ore; sedimentary rock interlaminated with carbonate of lead; phosphate rock from Ocean Island; crystallized gold in ankerite from Carter's Hill Gold Mine, Rockley.

3. By Professor W. R. Browne—Photographs of sandstone blocks on the rock-platform near Long Reef, which

would seem to indicate active present day erosion of the platform.

Notes were contributed by Mr. E. C. Andrews on the geology of Western Australia. The geology of the country about Perth was dealt with; the Pre-Cambrian granites, which are of two types, gneissic and massive, the Perth Artesian Basin, the laterite capping and the Darling Range, which the lecturer suggested was in part due to a warp relieved in places by faulting.

Notes were given on the geology of the Meekatharra region, including Pre-Cambrian sediments and igneous intrusions and the Permo-Carboniferous rocks forming the Carnarvon Artesian Basin.

The notes were discussed by Dr. Clapp, who gave some account of his observations as to the structure of North-West Cape, where folding of late Tertiary age is developed: he also contributed some remarks on the occurrence of laterite.

Dr. W. G. Woolnough dealt with the distribution of laterite and argued against the probability of warping as a factor in the formation of the Darling Scarp.

Also discussed by Messrs. L. J. Jones, H. G. Raggatt and the Chairman.

Monthly Meeting, 19th December, 1924.

Professor Cotton in the Chair.

Six members were present.

EXHIBITS:

1. Professor W. R. Browne—Photographs illustrating movements of the strand line Kiama; alunite banded in reddish Pleistocene or Tertiary rocks underlaid by Pre-Cambrian glauconitic sandstone, Stansbury, Yorke's Peninsula.

SECTION OF AGRICULTURE.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF AGRICULTURE.

Annual Meeting, 12th May, 1924.

Professor R. D. Watt in the Chair.

The election of officers resulted as follows:—Chairman—Principal E. A. Southee, O.B.E., M.A., B.Sc.Agr.,; Vice-Chairman—Professor R. D. Watt, M.A., B.Sc.; Honorary Secretaries—P. Hindmarsh, M.A., B.Sc.Agr., R. J. Noble, Ph.D., B.Sc.Agr.; Committee—A. A. Hamilton, H. W. Potts, F.L.S., F.C.S., A. E. Stephen, F.C.S., Professor J. D. Stewart, B.V.Sc., M.R.C.V.S., W. L. Waterhouse, M.C., B.Sc.Agr., D.I.C.

Professor Watt spoke upon the topic of "An Agricultural Objective for New South Wales." The State, he claimed, should have the following objectives for the next decade:—(1) Doubling the present area under cultivation; (2) increasing the average yield per acre of the principal crops by fifty per cent. This address was successfully broadcasted.

Monthly Meeting, 10th June, 1924.

Principal Southee in the Chair.

Mr. J. Shelton spoke upon "Strength in Wheat." High milling quality was treated at length. The effect of climate upon quality, the relation of gluten to strength, and the inheritance of strength in wheat, were dealt with. In reference to inheritance of strength, both one and two factor differences have been maintained.

Mr. Farnsworth exhibited a specimen of *Phytolacca octandra* showing variegated foliage. Mr. Waterhouse exhibited (*a*) a natural cross of Hard Federation and Yandilla King wheats; (*b*) some examples of Mr. Salter's multiple crosses.

Monthly Meeting, 14th July, 1924.

Principal Southee in the Chair.

Mr. J. K. Taylor spoke upon "Some Aspects of Nitrogen Fixation by Wheat Plants." The lecturer presented the results of his work with pot cultures, in which nutrient solutions contained varying amounts of nitrogen. Final analyses showed gains of 34 and 38 per cent. of the original nitrogen supplied. The increases were most marked in the nitrogen starved series.

Mr. Shelton exhibited a chart from Longerenong College illustrating the relation between amount of rainfall during the growing season, and the yield of wheat per acre.

Monthly Meeting, 11th August, 1924.

Professor R. D. Watt in the Chair.

Mr. W. H. Paine submitted a paper upon "Some Noteworthy Instances of the Use of Meat Concentrates as Animal Foods." This was read by the Secretary. A series of experiments, in which evaporated abattoir soup waters were fed to stock, were described. These concentrates were tested against linseed meal. Dairy cattle, pigs and sheep were used in the tests. It appeared that the residues provided a satisfactory concentrated foodstuff.

Mr. Waterhouse exhibited some specimens and photographs of sectional chimeras in wheat seedlings.

Monthly Meeting, 8th September, 1924.

Principal Southee in the Chair.

Professor Griffith Taylor spoke upon "Arid Australia." He described two traverses across Australia, and dealt with the question of absence of settlement. The 15 inch rainfall line is the chief economic division in New South Wales. The lecturer dealt with sun spot curves, homoclines, climate and health.

Monthly Meeting, 13th October, 1924.

Principal Southee in the Chair.

Mr. R. G. Cameron spoke upon "Agriculture in Education." He discussed the place of Nature Study and Gardening in the Primary School Curriculum. Reference was made to Cambridge "Refresher" Schools, to the Agricultural Scholarships for the children of agricultural labourers, and to the Danish High Schools.

Mr. Waterhouse exhibited (*a*) a natural cross between Federation and Indian 12 wheats; (*b*) grass tufts in *Avena sterilis;* (*c*) a smut (*Ustilago tritici*) attacking the flag; (*d*) head smuts attacking the flag of *Danthonia* and *Dichelachne;* (*e*) *Puccinia triticina* showing 90 per cent. infection on wheat.

Monthly Meeting, 10th November, 1924.

Professor R. D. Watt in the Chair.

Mr. Clunies Ross spoke upon "The Problem of control of the commoner parasitic diseases in New South Wales." The parasites of the horse, cattle and sheep were dealt with in turn.

Mr. Waterhouse exhibited (*a*) an F_1 plant (Federation $\times$ California Club) attacked by *Erysiphe graminis,* and showing a head attack. Both conidial and perfect stages

were present; (*b*) a natural cross between a polish and a macaroni wheat, showing clean segregation.

Monthly Meeting, 8th December, 1924.

Principal Southee in the Chair.

Dr. W. G. Woolnough spoke upon "The condition of industry in the far interior of Australia." The lecture was illustrated by lantern slides.

SECTION OF INDUSTRY.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

Monthly Meeting, 21st May, 1924.

At the pre-lecture meeting of members, Mr. S. E. Sibley was elected as Chairman of the Section for the coming session. Dr. Greig-Smith was re-elected as the Hon. Secretary.

Mr. S. E. Sibley in the Chair.

Mr. L. G. Klem, of Mineral Earths Limited, gave an address upon "The Mineral Earths and their Industrial Application." The earths included china clay, used for pottery purposes and paper making, the secondary clays, used for pottery mixtures and brick-making, asbestos, diatomaceous earth, fuller's earth, magnesite, talc, felspar, Cornish stone, mica, fluorspar and barytes. Their sources and uses were treated at length, and the lecturer had embodied his remarks in a pamphlet which was distributed to those present.

11th June, 1924.

Through the kindness of Dr. J. J. C. Bradfield, M.E., Chief Engineer, Metropolitan Railway Construction, the members went over the works of the City Railway and saw the progress that had been made in the construction between St. James and the Central Station.

Monthly Meeting, 18th June, 1924.

Mr. S. E. Sibley in the Chair.

Mr. J. E. Bishop read a paper upon "The Learning of Trades," in which he pointed out that much of the

apprentice's time was occupied in subconsciously absorbing technical matter which would be of importance to him later. Hard and fast rules about the period of apprenticeship, the age for beginning and the numbers of apprentices to the journeymen were to be deprecated owing to variations in the natural ability of the individual.

9th July, 1924.

At the invitation of the directors, the members visited the establishments of the British-Australasian Tobacco Company at Raleigh Park, of Wills and Company and of S. T. Leigh and Company. In the former, the various processes through which the leaf passes before becoming the finished cigar, cigarette or plug were seen in detail, and at the latter the making of boxes of tin and cardboard, the printing on metal and the production of collapsible metal tubes, were observed.

Monthly Meeting, 16th July, 1924.

Mr. S. E. Sibley in the Chair.

Mr. H. V. Bettley-Cooke gave an address upon "Dyes and their Uses," in which he pointed out that, as dyes were used to colour various materials, they must be considered from the point of view of the conditions under which they would be subjected when in use. Curtains, for example, would be subjected to strong light compared with a table-cloth. Consequently the dye for curtains must be more light-fast than that for a table-cloth, and conversely the dye for a table-cloth must be more washing-proof than that for curtains, and also more acid-proof, as table-cloths are more frequently washed and are subject to staining by fruit.

Skill and experience are required for the dyeing of mixed materials, for a synthetic dye may give to wool

one colour and to cotton another. The dyeing of various substances, ranging from sweets to hats, was considered, and remarks were made upon the uses of the basic and the acid dyes, with their most suitable mordaunts.

20th August, 1924.

Upon the invitation of Mr. B. King, the members visited the works of the Australian Glass Manufacturing Company at Moore Park and saw the various stages in the manufacture of glass bottles, those made in small quantities by hand and those in large quantities by automatic machines.

Monthly Meeting, 17th September, 1924.

Mr. S. E. Sibley in the Chair.

Mr. R. Grant read a note upon "Mucin-forming Bacteria" which had been isolated from milk, soil, bread and other substances. *Bacillus lactis viscosus* (Adametz) was the usual slime producing bacterium in Sydney milks, and *Bac. panis viscosus* was the cause of ropy bread frequently met with in country bakeries.

The Hon. Secretary gave an instance of *Dematium pullulans* producing dark stains on painted woodwork.

Monthly Meeting, 15th October, 1924.

Mr. S. E. Sibley in the Chair.

Mr. Ben. W. G. Phillips gave an address upon "Gems and their Cutting," in which he described at length the various opal fields of Australia. Localities have their particular kind of stone each in a different kind of matrix. Some, as at Lightning Ridge, are at a depth of 50 feet; others, as in Queensland, at 5 feet. The latter are found in wet soil and, losing moisture, soon crack and split. Diamonds occur in various parts of Australia, but chiefly

in the Inverell district of New South Wales. The Australian stone is cross-grained, difficult to cut, and harder than the South African gem. On account of the grain it is not so firmly gripped in the setting, and is not used for drilling purposes. They range in weight from 1 to 6 carats. Sapphires occur with topaz and other stones in the Inverell district. Pleonaste, a black spinelle, is a new gem from Queensland and is used in conjunction with diamonds in jewellery.

Monthly Meeting, 19th November, 1924.

Mr. S. E. Sibley in the Chair.

Mr. A. C. Sherwood, of Home Recreations Limited, gave an address upon "The History and Development of the Modern Phonograph," during which he illustrated his points by means of the phonograph and the piano, under the care of the Misses Massey and Brown. An ancient Chinese record suggests that a method of retaining and reproducing the human voice was known, and Roger Bacon had a machine which spoke three words. The phonautograph of Scott (1856) was the precursor of the modern phonograph, and in 1877 Edison published his invention. At first tinfoil was used, then a wax cylinder, and Berliner in 1887 introduced the disc.

Manufacturers endeavour to minimise the surface noise by various methods, such as the balancing of the needle arm and the use of bamboo needles. Mention was made of the educational value of the phonograph in the pronunciation of foreign words and the method of expression in singing.

SECTION OF PHYSICAL SCIENCE.

ABSTRACT OF PROCEEDINGS

OF THE SECTION OF

PHYSICAL SCIENCE.

In accordance with Rule XLI., the Council of the Society established a Section of Physical Science on 24th September, 1924.

An inaugural meeting of those interested was held in the Library of the Royal Society, at 4.30 p.m. on Thursday, 16th October, at which the following officers were elected: —Chairman—Professor O. U. Vonwiller; Honorary Secretaries—Professor V. A. Bailey and Mr. J. J. Richardson; Committee—Rev. Dr. E. F. Pigot, Professor J. P. Madsen, Messrs. A. B. Ranclaud and E. M. Wellish. It was decided by general agreement that the Section should meet on the third Thursday of each month at 4.30 p.m. in the Library of the Society.

First General Meeting, 20th November, 1924.

Professor O. U. Vonwiller in the Chair.

The until recently generally accepted theory of stellar evolution having been reviewed, the subsequent exposition of the new theory, due to Eddington, according to which the temperature of a star is essentially a function of its mass, and radiation is the result of a degradation of matter into energy, revealed the importance of the new theory in the attainment of a solution to the fundamental problems of cosmogony.

The speaker, Mr. J. J. Richardson, advanced a theory that under certain circumstances the condition of radiative equilibrium in the interior of a star might be disturbed, either by a time accumulation of energy or a spontaneous release of atomic energy, in which case radiation pressure would be in excess of pressure due to gravitation, and a satisfactory explanation thus afforded of the phenomena associated with long period variable stars.

INDEX.

Sydney

F. W White, Printer, 344 Kent Street

1925.